DEVELOPMENT OF A DECISION SUPPORT SYSTEM (DSS) FOR MALAYSIAN ADULT WEIGHT MANAGEMENT

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ABSTRACT

The main objective of this study is to develop an electronic knowledge-based decision support system (DSS) for the use of experts, specifically nutritionists and dieticians, as well as Malaysian adults for effective weight management. The system will allow the user to keep track of their daily food consumption and energy expenditure to prevent them from getting overweight since obesity is a prominent public health problem in Malaysia. It is also in line with goals of the National Plan of Action for Nutrition of Malaysia (NPANM) for the period of 2006 to 2015 to reduce overweight individuals and prevent obesity among Malaysians (MOH, 2006). In order to achieve this objective, implementation of the DSS is based on the System Development Lifecycle (SDLC) method that consists of five phases; (1) Study of the existing system; (2) System requirement and analysis; (3) System design; (4) System implementation and (5) System testing and operation. A usability study was also conducted involving thirty participants consisting of experts and the public using a web-based test instrument. This study is significant in testing and measuring users' interactions and satisfaction with specific aspects in dealing with the *WeightExpert* DSS prototype. The results showed that participants' reactions to the *WeightExpert* DSS prototype were positive, especially with respect to ease of use, straightforwardness, reliability of data bases, and the well-structured design of its interface. However, the study did identify some areas where the usability of the application can be improved, particularly with regard to flexibility of access to the application, storing of daily record for the projected timeline and addition of up food records from Asean countries food databases.

ABSTRAK

Objektif utama kajian ini adalah untuk membangunkan sistem sokongan keputusan (DSS) elektronik berasaskan pengetahuan untuk kegunaan pakar-pakar khususnya ahli nutrisi dan dietetik dan juga orang dewasa di Malaysia untuk pengurusan berat badan yang efektif. Sistem ini akan membenarkan pengguna untuk menjejaki pengambilan makanan harian dan penggunaan tenaga untuk mencegah mereka dari terlebih berat badan memandangkan obesiti sudah jelas sebagai masalah kesihatan awam di Malaysia. Ia juga selari dengan Tindakan Rancangan Negara untuk Nutrisi Malaysia (NPANM) bagi tempoh perancangan 2006 sehingga 2015 untuk mengurangkan individu-individu terlebih berat badan dan mencegah obesiti di kalangan Malaysia (MOH, 2006). Untuk mencapai objektif ini, pembangunan DSS berdasarkan kaedah Kitar Pembangunan Sistem (SDLC) yang terdiri daripada lima fasa iaitu (1) Kajian ke atas sistem sedia ada; (2) Keperluan sistem dan analisis; (3) Rekacipta sistem; (4) Pembangunan sistem dan (5) Pengujian sistem dan operasi. Kajian penggunaan juga telah dijalankan melibatkan tiga puluh peserta mewakili pakar-pakar dan orang awam menggunakan alatan ujian berasaskan web. Kajian ini penting untuk pengujian dan pengukuran interaksi dan kepuasan pengguna-pengguna dengan aspek spesifik ketika berurusan dengan prototaip *WeightExpert* DSS. Keputusan menunjukkan reaksi peserta-peserta kepada prototaip *WeightExpert* DSS adalah positif, terutamanya mudah untuk diguna, jelas, sumber data yang dipercayai dan struktur paparan yang tersusun baik. Walaubagaimanapun, kajian ini mendapati beberapa area kepenggunaan aplikasi boleh diperbaiki, terutamanya akses yang fleksibel kepada aplikasi, simpanan rekod harian untuk jangkamasa perancangan dan tambahan lebih banyak rekod makanan dari pengkalan data makanan negara Asean yang lain.

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LIST OF ABBREVIATIONS

DSS	Decision Support System
RNI	Recommended Nutrient Intake
MOH	Ministry of Health
DFD	Data Flow Diagram
ERD	Entity Relationship Diagram
BMR	Basal metabolic rate
PA	Physical activity
MANS	Malaysian Adult Nutrition Survey
PAL	Physical activity level
BMI	Body mass index
SDLC	System Development Lifecycle
MET	Metabolic equivalent

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CHAPTER 1

INTRODUCTION

1.1 Background

Development of a weight management application based on the concept of energy balance tailored for Malaysian adults is needed in order to assist Malaysian nutritionists and dieticians in monitoring and in giving advice about weight management. Currently, these experts have to calculate manually energy intake and energy expenditure using Microsoft Excel since there is a lack of electronic applications developed for them so far. This can lead to arithmetic errors and is time consuming. Various electronic applications for weight management are available in the market either from abroad or in Malaysia itself that provides automatic calculation. However, there are still limitations in these tools as none yet produces analysis based on energy balance concept while internationally-made applications are most suited to their local community.

Developing a weight management application for experts is highly recommended to optimize their effort in tackling the enormous problem of overweight and obese adults in Malaysia which can lead to chronic diseases and disability. It will also facilitate these experts to focus on strategies for promoting a healthier lifestyle like public awareness campaigns for weight loss and maintenance, and prevention of weight regain. In addition, it can also be used by the public as a self-monitoring tool for their personal weight management. Principally, the fundamental cause of obesity and being overweight is due to energy imbalance resulting from calories consumed through eating and drinking compared to calories burned through physical activity.

Hence, this thesis discusses a decision support system (DSS) for weight management of Malaysian adults using Filemaker Pro Advanced software, Nutrient Composition of Malaysian Foods (Tee et al., 1997), Compendium Physical Activities (Ainsworth et al., 2000) and Recommended Nutrient Intake (RNI) based on data from MOH (2005). This system focuses on adults within the age range of 18 to 59, where growth levels are considered to be stable. This period is also considered as a long period of lifespan that may contribute to many factors like profession, family and personal matter. Moreover, maintenance of a healthy body weight is important to minimize the risk of chronic diseases especially among adults who are overweight or obese.

1.2 Problem Statement

As of now, there are lots of weight management applications that have been developed globally. Most of the applications available in the market were developed by IT professionals and focuses on western diet regimes. However, in Malaysia, there is still an absence of an appropriate weight management application particularly developed for experts' and the public's regular uses. Electronic applications in Malaysia mostly provide BMI calculators and calorie burners separately, or one of the other. Physical activities in calorie burners are also not varied according to different intensities. Besides that, there are also improper links between physical activity calculation and nutrient intake calculation to support energy balance calculation.

On top of that, it is also timely that the Food Composition Table is made available as a database with a mechanism for updates by authorized researchers, which then could be made available for all experts. This was highlighted in the nutrition research priorities established based on the National Plan of Action for Nutrition of Malaysia from 2006

until 2015 (MOH, 2009). This became necessary as the first Food Composition Table, which was published in 1997 (Tee et al., 1997), had not been updated and improved but is still used by experts, food scientists, food safety personnel, policy makers and the rest of the industry for a variety of purposes.

Meanwhile, in the context of a Malaysian diet expert's expectation for a weight management application, the distinctive food database and physical activity measurements in applications designed by international developers are not optimized to the local community and is for a different target group of people. Malaysian Ministry of Health had come up with Malaysia Dietary Guidelines and Recommended Nutrient Intake suitable to our local people and the data may have a value gap with the aforementioned applications. To start with, shortcomings of several state-of-the-art applications were identified and listed in Table 1.1.

Table 1.1: Limitations of a few current weight management applications in relation to Malaysian users

	Application Name	**Developer**	**Application Description**	**Limitations for local used**	**Reference**
1	Nutritionist Pro	Axxya Systems, United States	Nutritionist Pro provides thorough nutrient analysis of diets, menus and recipes.	Food intake assessment based on American Dietary Guidelines and their Recommended Nutrient Intake. Thus, there is a difference in recommended food serving sizes and nutrient intake compared with recommendations made by the Malaysian Ministry of Health.	http://www.nutritionistpro.com/dietanalysis.php

Table 1.1, continued

	Application Name	Developer	Application Description	Limitations for local used	Reference
2	Energy Balancer	Medibank, Australia	Energy Balancer helps users balance the food they eat with everyday activities. It is designed to complement users' existing diet plans and exercise regimes and helps them to make healthier decisions.	The options for food and activities are not extensive. Also, Medibank does not have details on the calculations made for energy intake and energy expenditure to assess energy balance status, making it unsuitable for dietary professionals to use it.	http://www.medibank.com.au/healthcover/mobile/energy-balancer.aspx
3	Diet Pro 2005	Radium Technologies, California	Diet Pro 2005 is weight management software for Windows operating system.	Diet Pro 2005 has no database to support an exercise log. Without this database, it becomes very difficult to determine the relationship between respondent physical activities and caloric burn rate.	http://www.dietpro.net/
4	DietMaster 2100	Lifestyles Technologies, CA	DietMaster 2100 is comprehensive and user-friendly software that monitors the impact of people's diet and fitness lifestyles on their overall health and well-being. It is highly recommended for professionals involved in nutrition and fitness consulting.	DietMaster 2100 offers nutrient databases for Canadians and Australians and is customized to their weight and volume measurements, as well as the brands, products and culinary items found in those two countries.	http://dietmastersoftware.com/products/professional-nutrition-software/dietmaster-professional

Table 1.1, continued

	Application Name	Developer	Application Description	Limitations for local used	Reference
5	DietPLUS	Tony Ng K W, Department of Nutrition and Dietetics, School of Pharmacy and Health Sciences International Medical University (IMU), Bukit Jalil, Kuala Lumpur, Malaysia	DietPLUS functions as a '2-in-1' food composition database plus as a rapid calculator for nutrient intake.	DietPLUS was developed using an Excel format and is used as a teaching and research tool. It only contains energy intake calculations.	Ng TKW (2010)
6	NutriWEB	Nutrition Society of Malaysia	NutriWEB provides health tools such as Waist Hip Ratio calculator, calculator, Calorie burner and heart rate calculator.	It does not provide energy balance calculator which should accompany calorie consumption and calorie burner calculations.	http://www.nutriweb.org.my/
7	Nutrical	Institute of Medical research with the help of Malaysian Neura Media Technologies Sdn Bhd	Nutrical facilitates the calculation of nutrient content in meals, menus, recipes and any food combinations based on a Malaysian food composition database of more than 700 locally available foods.	Nutrical only calculates individual calorie requirements including calories contained in foods.	http://nutriweb.org.my/article.php?sid=5
8	Weight Watchers	International company based in the United States	An online website for American population weight management.	Weight Watchers have all the components as proposed by *WeightExpert* DSS but all the data from food database and physical activity measurements used in this system are optimized to the American community.	http://www.weightwatchers.com/index.aspx

Referring to the identified limitations in Table 1.1, a comprehensive weight management application should be developed to assist Malaysian nutritional experts to consult Malaysian adults needing sound weight management guidance to help meet their personal health and fitness goals. The application would also be useful for experts in designing weight management programs for their respondents and their progress could be well-monitored accordingly. The public can also use it to self-monitor their body weight, and even for educational or research purposes.

1.3 Project Objectives

The aim of this study is to develop an electronic knowledge-based decision support system (DSS) for the use of experts and Malaysian adults for effective weight management by keeping track of the user's daily food consumption and energy expenditure.

Specifically, the objectives of this study are:

1. To develop a DSS for Malaysian adult weight management that comes with an automatic calculator for energy intake and energy expenditure, with built-in electronic Malaysian Food Database, Malaysian Dietary Guidelines and Recommended Nutrient Intake (RNI).
2. To test users' interactions with the *WeightExpert* prototype.
3. To measure users' satisfaction according to specific aspects in using the *WeightExpert* prototype.

1.4 Project Scope

This study involves the development of a Decision Support System (DSS) for Malaysian Adult Weight Management named *WeightExpert*. This study focuses on the data preparation process for a Malaysian food database and physical activity database including data digitization and normalization, design, development, user evaluation and implementation of the application. *WeightExpert* is executed as a standalone application and will be a great option for users looking for a simple set up where each database resides on their own machine and there are no shared databases.

1.5 Research Contributions

Upon completion of this study, it is rather practical to expect all the project objectives as listed above to be met. Furthermore, the study is expected to have technological impacts, health impacts (on the health industry) and psychological impacts on the adult.

Technologically, the project provides:

- A comprehensive and quick reference database on Food Composition Table (Tee et al., 1997)
- A decision support system to calculate energy intake and energy expenditure automatically
- A tool for monitoring individual body weight by keeping track of food consumption and physical activity

Contributions to the health industry will be as follows:

- The project will revolutionize the way Malaysian adults go about monitoring their body weight

- It will educate the users on healthy food choices and adopting a more active lifestyle based on expert's advice. With this knowledge, the users will be better equipped to balance food energy intake with physical activities
- The system will provide automated energy balance calculation and will speed up weight management analysis by having automated calculation for energy intake from food consumption and energy expenditure from physical activity

1.6 Chapter Organization

This study is reported in five structured chapters. The content of each chapter is briefly outlined below:

CHAPTER 1: Introduction

This chapter describes the background of this study and justification for development of the DSS. Problem statement, research objectives, scope and research contributions of the study are described at the end of this chapter.

CHAPTER 2: Literature Review

This chapter elaborates on the literature review related to nutrition management and perspective of information technology, followed by discussion on current weight management trend among Malaysian adults, present prevalence of overweight and obesity revealed by the latest Malaysian Adults Survey (MANS) and World Health Organization (WHO). This chapter also justifies how a decision support system could aid the prevention of overweight and obesity among Malaysian adults from the findings.

CHAPTER 3: Materials and Methods

This chapter describe on the development materials and methodology used in this study. The explanation on the system development phases and prescribed procedures in the implementation process were described. This chapter also elaborates on the data sources used.

CHAPTER 4: System Development, Implementation and Testing

This chapter describes the three main steps performed in this study. The system architecture, relational database design and user interface design are described. This chapter also discusses the system implementation, system testing process and development tools used in this research. Explanation on the algorithm and calculation used in *WeightExpert* DSS to match different body weight, age and gender of an individual is included in the chapter as well.

CHAPTER 5: User Testing and Evaluation

This chapter covers on system evaluation by users. A user acceptance test was carried out here for expert to test and verify. A usability study of the prototype was also conducted on a sample of thirty participants with different backgrounds. The method used and components of the evaluation are described in detail along with results of the analysis.

CHAPTER 6: Discussion and Conclusion

This chapter discusses several issues such as the achievement from the development of the DSS, the importance of the *WeightExpert* prototype usability study to the research, and the weakness of the system. This chapter also covers the enhancement to be taken into account for future development.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter looks at the information technology and health perspective in order to specify the requirements for the design of *WeightExpert* DSS.

2.2 Decision Support System

The concept of a decision support system (DSS) is extremely broad and its definitions vary depending on the author's point of view (Drudzel et al., 1999). It can take many different forms and can be used in many different ways (Alter, 1980). Several definitions are shown in Table 2.1.

Table 2.1: Definition of Decision Support System (DSS)

Author	**Definition of DSS**
Finlay (1994)	A computer-based system that aids the process of decision making.
Turban (1995)	An interactive, flexible, and adaptable computer-based information system especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilizes data, provides an easy-to-use interface, and allows for the decision maker's own insights.
Keen & Scott Morton (1978)	A decision support system couples the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions.
Sprague & Carlson (1982)	An interactive computer based systems that help decision makers utilize data and models to solve unstructured problems.

According to Table 2.2, DSS can be summarized as a computer-based information system that supports either a single decision-maker or a group of decision-makers when dealing with unstructured (expert's advice) or semi-structured (combination of DSS solution and expert's advice) problems to contribute to effectiveness of decision-making. The DSS supports one or more decision-making activities carried out in the process.

In relation to this study, it is said to be healthcare decision making as it assists and supports experts in solving body weight management problem among adults and even provides a tool for the public to self-monitor their weight to maintain healthy levels. The process includes data collection of respondents from interviews (e.g. weight, height, age, sex) according to the framework of a diagnostic and therapeutic cycle (Figure 2.1). For each respondent, a diagnostic and therapeutic cycle can occur once (e.g. during the consultation of a respondent) or it may be repeated for body weight monitoring.

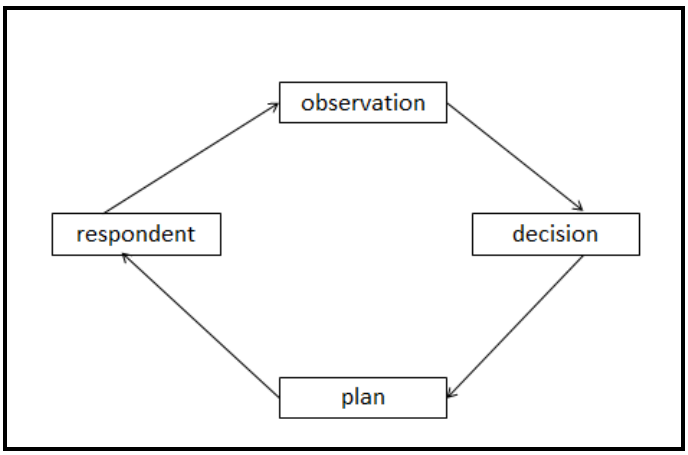


Figure 2.1: Diagnostic and therapeutic cycle

Therefore diagnostic conclusions based on examinations of a respondent are the basis for further therapeutic decisions made by an expert. In a healthcare decision-making process, an expert can be supported by information and communication technologies using an appropriate decision support system. Here, *WeightExpert* DSS comes into play

to help experts support their healthcare decision-making in an interactive way for monitoring of respondents' weight management.

There are also different types of DSS and one way to categorize decision support systems is provided by Power (2002). He introduces a framework, in which the term 'driven' is used, that points at the dominant functionality of the DSS (Table 2.2).

Table 2.2: DSS types and their characteristics (Power, 2002)

	Keywords	Other names	Platform	Methods	Examples
Document-Driven DSS	document databases, document retrieval, document analysis	/	Client/server systems, web	search methods, storage and processing methods and technologies	search engines
Communications-Driven DSS	communications, collaboration, groupware	/	client/server systems, web	network technologies	chats software, document sharing, online collaboration, net-meeting systems
Data-Driven DSS	manipulation of a time-series of data, query a database, historical data	Retrieval-Only DSS Business Intelligence	mainframe system, client/server systems, web	data warehouse, on-line analytical processing (OLAP)	Executive Information Systems (EIS), Geographic Information Systems (GIS)
Model-Driven DSS	model manipulation, simulation, optimization, rule (expert) models, analyze decisions, multi-criteria, decision tree	Model-oriented, Model based, Computationally oriented DSS	stand-alone PCs, client/server systems, web	optimization and analytical methods, operational research methods (quantitative methods)	choosing between many options ("the best" alternative: "the best" meal, "the best" car), scheduling,
Knowledge-Driven DSS	expert knowledge (expertise), knowledgebase, knowledge engineering, knowledge discovery	Knowledge based DSS, Expert system	stand-alone PCs, client/server systems, web	intelligent decision support methods, data mining, artificial intelligence methods, knowledge discovery methods, heuristic methods	medical diagnosis, equipment repair, investment analysis, financial planning, vehicle routing, production control and training

By referring to Table 2.2, knowledge-driven DSS has been selected in developing the application. The reason behind the selection is because it represents specialized knowledge and supports experts' decision making for Malaysian adult weight management in particular.

Experts can also expect benefits of *using WeightExpert* DSS as stated below (Alter, 1980; Power, 2002):

(i) Improve expert productivity

It is possible to save time associated with tasks connected to decision-making (Keen, 1978). This mean the experts' tasks should be accomplished in less time, be carried out more thoroughly in the same amount of time, or more appropriate tasks could be executed with less effort. For example, experts can save time on the energy balance calculation that encompasses calculation on energy intake and energy expenditure. The ability of the expert to process information and knowledge can be extended as well (Marakas, 2003).

(ii) Improve decision quality and problem solving

The *WeightExpert* DSS allows the expert to give fast responses on individual weight problems. In addition, the quality of problem solving and consultation can also be enhanced.

(iii) Facilitate interpersonal communication

The *WeightExpert* DSS provides interactive communication support by allowing two-way communication (Alter, 1980; Keen, 1989; Turban et al., 2007). It provides experts with a tool for weight management consultation and facilitates better communication with their respondent (Alter, 1980).

(iv) Improve decision-making skills

The *WeightExpert* DSS can promote learning for both healthcare industry and public. For example, it can act as a practical guidance tool for junior experts or for nutrition and dietetic research exercises and even for health care providers.

(v) Increase organizational control

Organizational norms and requirements can constrain the expert and ensure consistency across organizational units, subsequently making it clearer to the expert (Mallach, 1994). For instance, *WeightExpert* DSS provides a primary and enhanced Malaysian food database with a mechanism for updates by authorized researchers, which then could be made available for all experts. It is also an improvement over the first and currently used Food Composition Table (FCT) which was published in 1997 (Tee et al., 1997). The 1997 FCT is considered to be incomplete, lacking nutrient and non-nutrient components including bio-active compounds, anti-nutrients, contaminants, toxicants, and additives (MOH, 2009). There is also an urgent need to collate all existing data for macro-, micro- and non-nutrients scattered among various laboratories in the country into one primary database (MOH, 2009).

2.3 Energy Balance and Energy Requirements Principles

Basically, energy is another word for calories. Energy balance is the balance of calories consumed through food consumption compared to calories spent through physical activity. The standard unit of energy is the joule and human energetics are usually expressed in term of kilojoules (i.e. joules x 1000). A megajoule (MJ) is 1000 kJ. One kcalorie or Calorie = 4.184 kJ. A fundamental principle of thermodynamics states that

energy cannot ‘disappear’. Energy from food eaten has to be either excreted in the faeces, or absorbed by the body. Once absorbed, a small amount of energy is excreted in the urine as the by-product of protein metabolism and the rest of the absorbed fuel has to be metabolized for energy or stored in the tissue as protein, fat or as carbohydrate in the form of glycogen. Metabolized energy supports the making of new chemical compounds within the body, fuels the muscular activity required to breathe, digest food and maintain body posture, and also provides the energy for physical activity (James & Schofield, 1990).

Energy needs are determined by energy expenditure. Therefore, in principle, estimates of requirements should be based on measurements of energy expenditure. Components of energy expenditure include basal metabolic rate (BMR), physical activity, metabolic cost of food and metabolic cost of growth. Energy needs may be calculated based on the amount of time spent and the energy cost of various activities (MOH, 2005).

Physiologically, BMR is defined as the lowest rate of energy exchange in the body, which is related to the organization of bodily functions and production of body heat. Technically, it is defined as the rate of energy expenditure of a fasting and fully-rested individual in a thermo neutral environment, or can simply be defined as the minimal rate of energy expenditure compatible with life (MOH, 2005).

Since basal metabolic rate (BMR) is the largest component of energy expenditure, it has been adopted by the FAO/WHO/UNU Expert Committee (1981) as the basis for calculating all components of total energy expenditure. To obtain the total requirement, the estimate of BMR is multiplied by a factor that covers the energy cost of increased muscle tone, physical activity, the thermic effect of food, and where relevant, the energy

requirements for growth and lactation (FAO/WHO/UNU,1985). The equations for predicting BMR from body weight in Table 2.3 were applied for BMR calculation (MOH, 2005) as part of the *WeightExpert* DSS development.

Table 2.3: Equations for predicting BMR for adult Malaysians

(Ismail et al., 1998)

Age group	n	Formula	r	SE Mean	%Difference
Male					
18-30	84	0.0550(W) + 2.480	0.644	0.0363	13% WHO[2] 6% HR[3]
30-60	223	0.0432(W) + 3.112	0.501	0.0189	13% WHO 4% HR
Female					
18-30	131	0.0535(W) + 1.994	0.511	0.0263	9% WHO 6% HR
30-60	218	0.0539(W) + 2.147	0.519	0.0200	9% WHO 2% HR

[1] Ismail *et al.* (1998), BMR is expressed in MJ/day, W= body weight in kg.
[2] FAO/WHO/UNU (1985)
[3] Henry & Rees (1991)

2.4 Physical activity and energy intake

Physical activity (PA) is closely interrelated with energy intake. The working body requires energy and nutrients in order to fuel its activity and function. As opposed to energy intake, PA manipulates energy expenditure and regulates the use of fuels (Katarina et al., 2005). When prolonged strenuous PA is performed on a regular basis; it causes an approximate 250-350 kcal (Estelle, 2003) increase in overall energy turnover (Bell et al., 2004), and leads either to loss of body weight or need for an increase in food intake (Maughan, 1999). Consultation from the FAO/WHO/UNU (2004) also endorses the proposition that recommendations for dietary energy intake must be accompanied by recommendations for an appropriate level of habitual physical activity.

As has been noted, body weight is regulated by energy intake and physical activity whereby both parameters are influenced by genetic and environmental factors as stated in Figure 2.2.

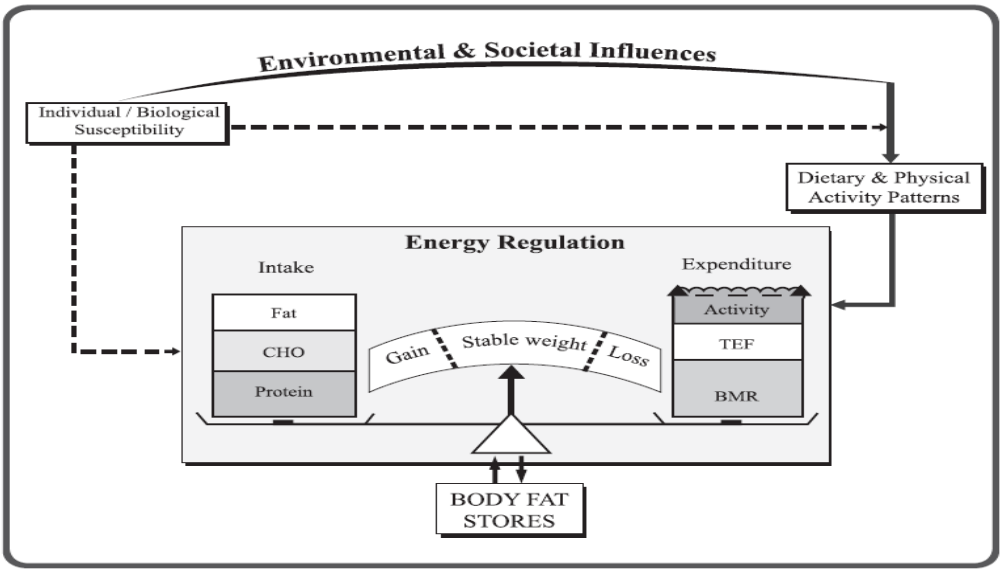


Figure 2.2: Influences on energy balance and weight gain: energy regulation TEF-Thermic effect of food; BMR–basal metabolic rate; CHO-carbohydrate (Adapted from MOH, 2006)

As shown in Figure 2.2 environmental factors within an individual's control that directly influence energy balance are dietary energy intake and physical activity. It was also deduced that maintaining a healthy body weight is possible by getting a balanced diet of fat, carbohydrate and protein.

2.5 Current nutrition and health status among adults in Malaysia

A rapid transition has generated marked changes in lifestyles, occupational patterns and dietary habits amongst Malaysians. These changes are increasingly reflected in the morbidity and mortality patterns of the population. The double burden disease theory is

very apparent: i.e. while great efforts are being made to combat communicable diseases and pockets of malnutrition, the past decade has seen degenerative diseases (e.g. coronary heart disease, hypertension, diabetes and obesity) becoming prominent. The epidemiological transition involving concurrent shifts in diet, physical activity and body composition appears to be accelerating and affecting the morbidity and mortality patterns in many regions of the world including Malaysia (Popkin et al., 2001).

This is proved by available data that suggests the prevalence of overweight and obesity in Malaysia have matched that of developed countries. The National Health and Morbidity Survey, NHMS II (MOH, 2006) reported a prevalence of 16.6% overweight and 4.4 % obesity in adults, and those in both urban and rural populations are equally affected (Lim et al., 2000).

In 2008, the Ministry of Health Malaysia conducted a Malaysian Adult Nutrition Survey (MANS) (Mirnalini et al., 2008), which was considered as the first and largest nutrition survey in Malaysia. It was aimed to provide detailed quantitative information on nutritional status, food and nutrient intakes and physical activity patterns on a nationwide representative sample of adult subjects between the ages of 18 and 59 years in 2003. The MANS (Azmi et al., 2009) reported an increase in prevalence of overweight and obesity, 27.0% and 12.0%, respectively, while the recent NHMS III survey (IPH, 2008) reported 29.1% and 14.0%, respectively (Figure 2.3).

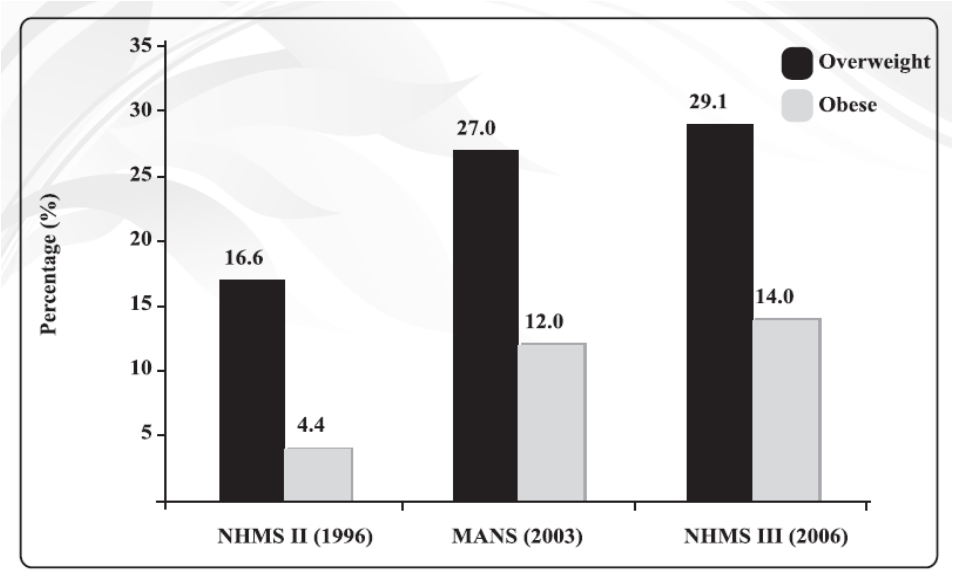


Figure 2.3: Prevalence of overweight and obesity in Malaysian adults (MANS, 2009)

Therefore, in line with concern on the rising numbers, the Specific Objective 1 of the National Plan of Action for Nutrition of Malaysia (NPANM) for the period of 2006 to 2015 sets out to reduce overweight and obesity among Malaysians (MOH, 2006).

To understand the problem of obesity in the context of energy balance, one clinical review had examined the matter in obese individuals (Estelle & Julia, 2003) and the role of increased physical activity in altering energy balance. According to the review, an obese individual who is weight-stable may be in perfect energy balance. Thus, the difference between a lean and an obese weight-stable person is simply the degree of adiposity for which their energy intake adjusts itself to their energy expenditure (Flatt, 1997).

To put it in in another way, obesity is a chronic condition that is the result of a positive energy balance, irrespective of the individual's current state of energy balance and which is now affecting Malaysian adults. Indeed, the threat of obesity starts to replace

the more common public health concerns including under-nutrition and infectious diseases, as one of the most significant contributors to illness and diseases.

Another factor leading to obesity is a physical inactivity which plays a major role in energy imbalance. Results of several studies (Yap et al., 2001; Victor, 1999) on the physical activity level (PAL) of selected groups of populations are shown in Figure 2.4. The results reveal that the adult PAL could be classified as moderate, based on the small segment of the population study. Increase of motor vehicle and television ownership may be indirect indicators of influences on the activity patterns of adults. The number of motor vehicles increased threefold from 2.3 million in 1980 to 7.6 million in 1997, while ownership of TVs increased from 1.1 million to 2.4 million during the same period (Department of Statistic Malaysia, 1998).

Subjects	Age (years)	Males			Females		
		BMR	TDEE	PAL	BMR	TDEE	PAL
Adolescents	12–14	5.08	7.89	1.55	4.80	7.09	1.48
Adolescents	16–18	5.76	8.64	1.50	5.02	7.64	1.52
Young adults	18–30	5.85	9.40	1.61	4.77	7.58	1.59
Adults	30–60	5.66	9.53	1.68	4.79	8.17	1.70
Elderly	>60	4.92	7.35	1.50	4.37	6.74	1.54
Armed forces	20–30	5.74	12.08	2.10	NA	NA	NA
Elite athletes	20–30	6.84	14.91	2.18	5.39	10.67	1.98

NA – not available.

Figure 2.4: Basal metabolic rate (BMR, MJ day^{-1}), total daily energy expenditure (TDEE, MJ day^{-1}) and physical activity level (PAL) (Ismail MN et al., 1997)

Conversely, too low of a body weight is also not good clinically, since it may impair an individual's health due to a higher risk of other medical conditions such as anaemia and low bone mass. Moreover, being underweight may leads to distortion of a young adult's appearance and can usually be attributed to an increase in the risk of eating disorders,

for instance anorexia and bulimia. Hence, there is no doubt that adults should maintain a healthy body weight range throughout their life supported by health advice from experts.

2.6 Physical activity in the prevention and management of obesity

Based on current evidence, recommendations for physical activity to prevent and manage obesity should ideally aim to create a negative energy balance, increase resting metabolic rate, increase sympathetic nervous system activation, increase rate of whole body fat oxidation, and increase fat free mass. Ultimately, there is an important role for exercise, over and above any effects on energy balance in overweight people. Regular physical activity has been shown to lower the overall risk for chronic diseases, minimizing the morbidity of obesity, and increasing adherence to dietary management.

A consensus at the Mike Stock Conference (2002) reported that moderate intensity activity of approximately 45-60 min/day is required to prevent the transition to overweight or obesity (Saris, 2002).

Furthermore, physical activity alone for the purpose of weight loss has been shown to be only moderately effective. Ross et al (2000) demonstrated that physical activity without caloric restriction can reduce obesity and improve insulin sensitivity. They found that 12 weeks of about 60 minutes of daily physical activity without caloric restriction produces a negative energy balance, approximately 700 kcal/day, resulting in substantial reductions in body weight (7.6 kg), total body fat (6.1 kg) and visceral fat (1 kg) in obese men. It appears that the failure of exercise to produce substantial weight

loss may be due to inadequate energy expenditure, or alternatively, compensation resulting from an increased energy intake or reducing of daily activity.

Physical activity may be more important in preventing weight regain after weight loss. Indeed, results from a meta-analysis by Miller et al (1997) found that the maintenance of reduced weight was significantly more effective in the one-year follow up of diet-plus-exercise group than diet-only group. Data collected on individuals in the National Weight Control Registry, who had lost $\geq$ 13.5 kg and maintained it for at least 1 year, demonstrated that weight maintenance is associated with high levels of physical activity. Individuals who maintained their weight reported energy expend of approximately 2 800 kcal/week through physical activity, corresponding to 80 min/day of moderate activity or 35 min/day of vigorous activity (Klem et al., 1997; McGuire et al., 1998 ; Schoeller et al., 1997).

The Centre for Disease Control and American College of Sports Medicine (Jane & Russell, 2006) guidelines provide evidence based recommendations that every adult should accumulate 30 minutes or more of moderate intensity physical activity on most, or preferably, all days of the week. Moderate intensity activities are better tolerated compared to high intensity exercise, especially by obese and older adults. These guidelines have been shown to be as effective in increasing physical activity and cardio respiratory fitness as the traditional, more prescriptive guidelines but are more effective in terms of long term compliance.

2.7 Summary

Hence, by using *WeightExpert* DSS, it is expected that a more precise determination of balanced calorie intake (food intake) with corresponding calorie expenditure (calories expended through physical activity) can be achieved as it functions as a decision support tool to analyze adult body weight, to keep track of food consumption and energy expenditure based on the total daily estimation of energy requirement. It also includes information about risk factors based on body mass index (BMI) and waist circumference.

In addition, the DSS could assist experts in improving daily dietary intake and exercise regimes for Malaysian adults in order to attain a better quality of life for the present and future generations (Chee et al., 1997), and can also educate the public proper weight management methods to avoid some kind of ‘yoyo’ effect on the body.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter elaborates on the methodology and data sources used in this study. The purpose of this chapter is also to clarify steps used throughout *WeightExpert* DSS development to achieve the research objectives.

3.2 Project Development Methodology

In this study, the Systems Development Life Cycle (SDLC) methodology was used to accomplish the development of *WeightExpert* DSS. The SDLC methodology is a conceptual model that describes stages involved from the beginning phase of the study until the end of the system development process. In general, the SDLC model involves the study of the existing system, identifying system requirements, preparing proposed system design, implementing the system and evaluating or testing the system to determine the effectiveness of the system, as summarized in Figure 3.1. This study uses the methodology as described in the SDLC model, i.e. to carry out research on current systems developed both locally and internationally, to identify system requirements that meets the needs of the experts, to design an appropriate system that suits the data used, to implement the proposed design as well as to perform evaluation by experts and the public on the *WeightExpert* DSS prototype.

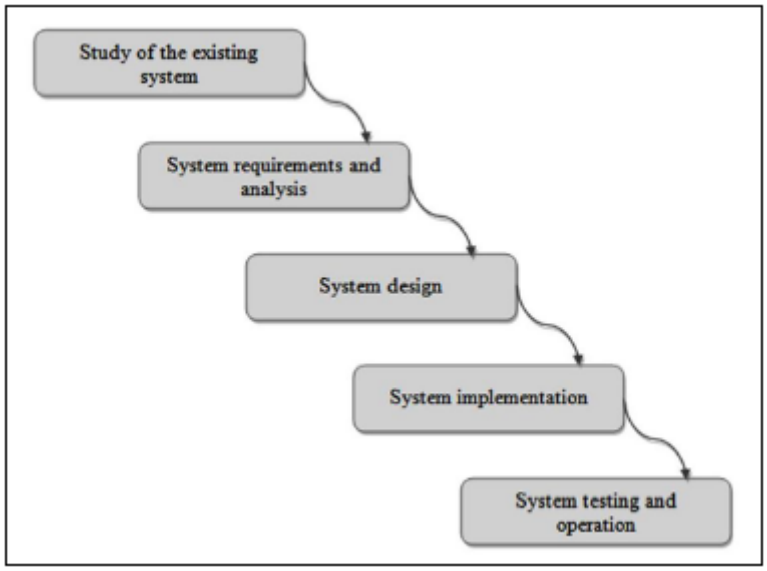


Figure 3.1: The flow of Systems Development Life Cycle (SDLC) methodology

3.2.1 *WeightExpert* DSS Development Phase

In order to implement the *WeightExpert DSS*, the system development procedures were carried out in five major phases according to the SDLC methodology model as described above. The five major phases are the information gathering and literature review phase, identification of the system requirements phase, designing of proposed system phase, system implementation phase and finally system testing phase. The explanations of each phase are as follows.

(i) Information gathering and literature review phase

Literature review is the preliminary stage in this study. It is very important to gather information on existing weight management applications as well as current public health problems among Malaysian adults. Information gathering regarding previous and ongoing studies is essential in identifying the necessary scope of the study as well as the importance of the study in order to achieve the objectives. The information was gathered from experts via interviews, while the

pros and cons of current applications were found through online articles, reference books, research paper presentations, and websites. This phase is also significant in order to solve the problem stated.

(ii) Identification of the system requirements phase

During this phase, the project requirements analysis and research on the basis architecture was performed. Based on the findings acquired during the literature review phase, the system requirements identified indirectly allows the production of a *WeightExpert* DSS prototype design to answer any arising problems. Suggestions for solving the problems are given in the form of logical modules to be studied before the implementation. A high-level of understanding has been developed through visualization using influence diagram. It allows the working out of connections between inputs and outputs without precisely specifying the relationships involved (Figure 3.2)

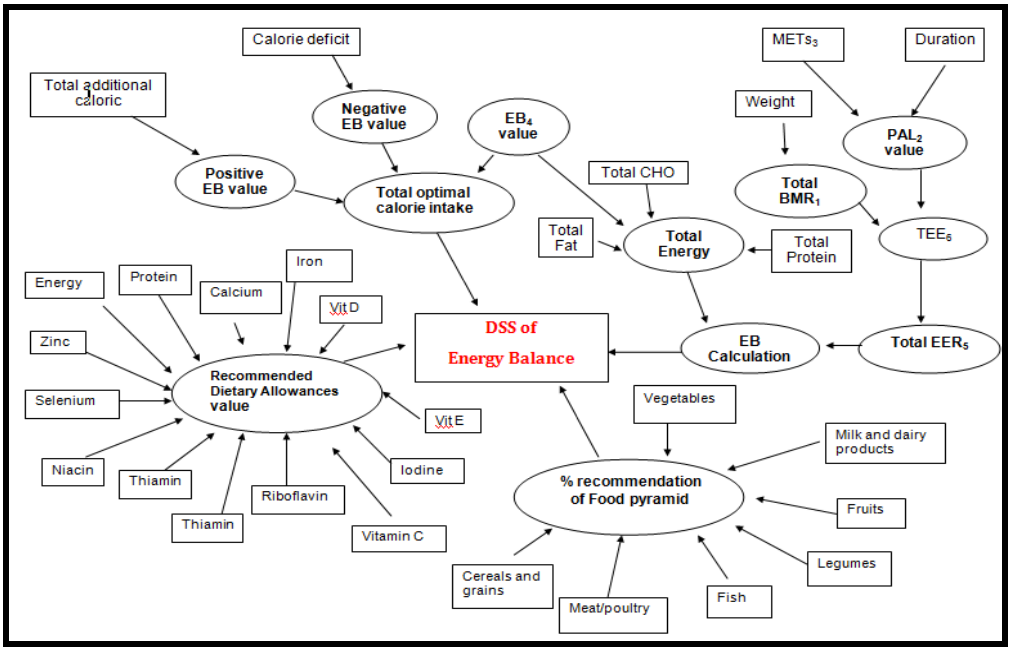


Figure 3.2: Influence Diagram of *WeightExpert* DSS

The collection and preparation of data was conducted in this phase as well. Three major steps in preparing the DSS data were searching and collecting data from particular sources, digitizing information obtained and executing data normalization and data validation.

(iii) System design phase

System design phase is the stage where the overall architecture of the *WeightExpert* DSS in terms of the architecture design, interface design, database and file specifications, and application design is decided. Primary output of this phase is system specifications. Here, data modeling process was carried out for application and database design which are system workflow, data flow diagram (DFD) and entity relationship diagram (ERD).

(iv) System implementation phase

Following the system design phase is the system implementation phase. In this stage, logical modules which have been designed during the previous phase were translated into physical modules structure. The physical structure reflects the actual design of the system which is then transformed into database structure format.

(v) System testing phase

The system testing phase is a process of reviewing the *WeightExpert* DSS. This procedure investigates the functionality of the DSS. In this study, the DSS has been tested to check the functional elements and to inspect the level of overall system effectiveness before the system is allowed to be used.

3.2.2 System Development Process Workflow

This study was conducted as described by the specific phases mentioned above. The scope of work and total time spent for each phases are also different. SDLC methodology is used as a guide and is changed according to the suitability of the work in this study. Figure 3.3 shows the summary of the two phases conducted throughout the system development process.

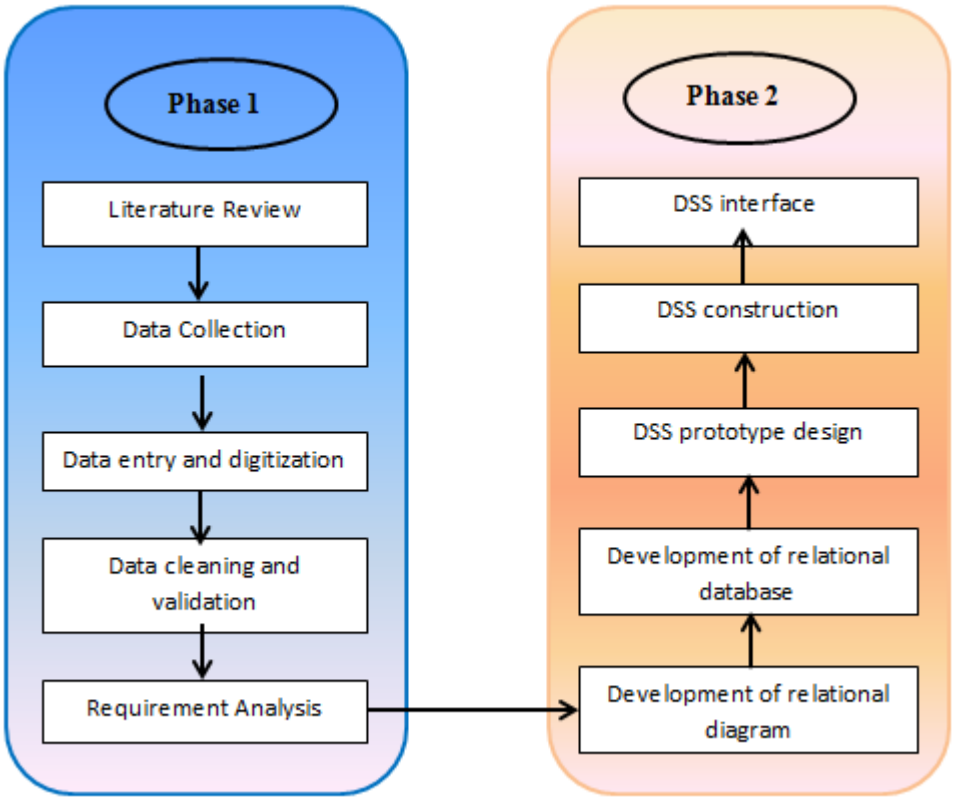


Figure 3.3: Workflow of the system development process

(i) The collection and preparation of data

This study involves the process of data collection and preparation through two different procedures. The data used in this system is a nutritional scientific data consisting of a large number and various types of data. Three major steps in preparing the DSS data are conducted i.e. the process of searching and collecting

data from particular sources, digitizing information obtained and performing data cleaning and validating process. Additionally, the literature review is also conducted to gather related information on the related existing system. Details during literature review phase were obtained from research journal articles, books and information from the website.

(ii) Analysis of system requirements

The system requirements analysis is based on the findings of the literature review and data collection phase. Analysis of scientific data and the structure of the system development are done. The types of scientific data collected and also the structure of the system development framework are discussed in order to ease the system design process. Besides, functional and non-functional requirements are identified to provide proposed solutions which will be applied when designing the system.

(iii) The system design process

Once all the requirements are identified and prepared, the process of designing the skeleton of the system construction is executed using CASE Studio version 2.0 software. The design is displayed in an easy to understand diagram accompanied with the required descriptions. In this study, the system design process is carried out by creating the relational database model and designing the DSS prototype which will be used during the system implementation process.

(iv) System implementation process

The completed system design will be used as a basic guideline in building the actual system. The design of the flow of the system will be used in the

implementation process of the actual physical form which later can be operated by the users. Conceptually, relational model design is used to develop the actual database using File Maker Pro 10 Advanced software.

(v) System testing process

Finally, the system is tested by the user to check and analyze the effectiveness and the functionality of each of the functions available on the system. System testing process is done where a user is needed to access the developed system and use every function provided in the system. In addition to the system functionality, the purpose of this testing procedure is to ensure that every function is available to deliver information correctly and to get feedback from the user on the suitability of the overall system.

The following Figure 3.4 briefly describes the flow of the system development process

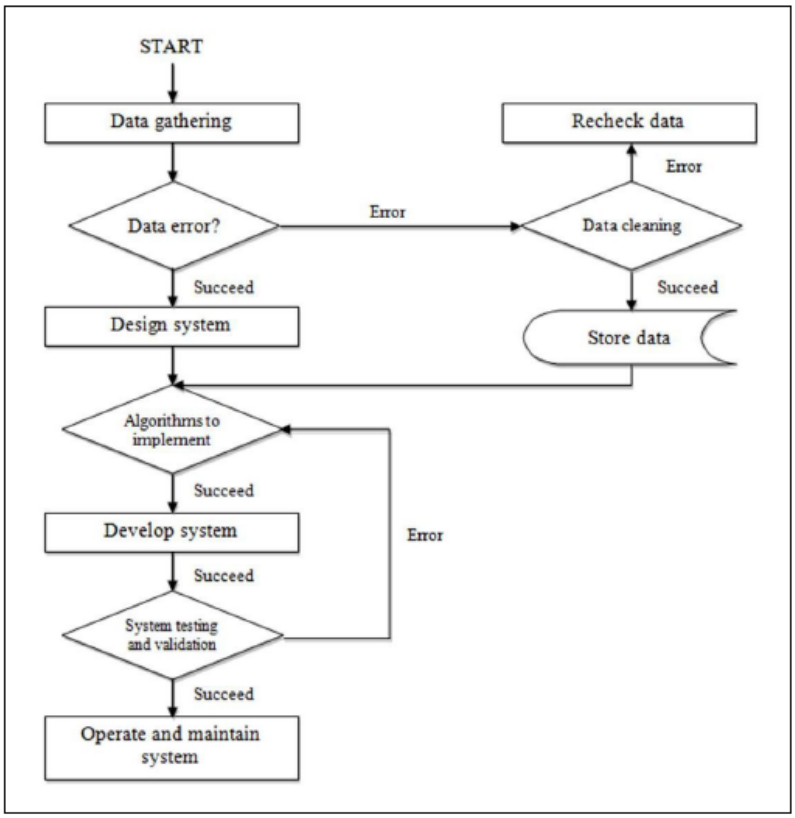


Figure 3.4: Flowchart of the development process

3.3 Data Source

Data sources used were based on the references below:

1) Nutrient Composition of Malaysian Foods 4th edition by Tee E Siong, Mohd. Ismail Noor, Mohd Nasir Azudin, Khatijah Idris, c/o Institute for Medical Research, Kuala Lumpur, 1997.
2) Compendium of physical activities: an update of activity codes and MET intensities by Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR Jr, Schmitz KH, Emplaincourt PO, Jacobs DR Jr, Leon AS. Med Sci Sports Exerc. 2000 Sep; 32 (9 Suppl): S498-504.
3) Expert advice via interview
4) Recommended Nutrient Intake (RNI) for use in Malaysia (MOH, 2005)
5) Malaysian Dietary Guidelines (MOH, 2010)

Focusing on the data collected from the original book and journals, data digitization process is carried out where the data is extracted into digital format and stored in the form of relational tables in File Maker Software database. Data cleaning process is then performed to ensure the accuracy of data, no data duplication or data missing happened during digitization process. The food database contains 783 food records while physical activity database contains 605 physical activities records. Food database and physical activity database are developed to allow the storage of data in order to preserve the information in which the resource was stored in the original printed book and journals. Besides, the development of the databases can be used for research and education purposes.

3.4 Summary

This chapter focuses on the methods with explanations on how data was obtained and how this study was conducted. Research methodology is important to ensure that the study is done to achieve the objectives and ensure the implementation process goes on smoothly and systematically. The methodology is a guideline to build the proposed *WeightExpert* DSS. This chapter also discusses the workflow throughout this study. The workflow of the research discusses about the data source and the construction of databases is done in this study.

CHAPTER 4

SYSTEM DEVELOPMENT, IMPLEMENTATION AND TESTING

4.1 Introduction

Description of system development will cover on system requirement and analysis and system design. The system requirement and analysis is one of the phases in SDLC methodology that has been described in the previous chapter. This phase plays an important role in conducting the analysis process on some important aspects before developing the system. This requirement analysis is also important to ensure the project development process is able to run smoothly and can be done systematically. System requirement analysis process begins with gathering information on requirements, which can be obtained in various ways from different resources, followed by identifying the importance of the requirements applied during project development, and finally documenting the identified requirements in a specific documentation. The documentation of requirements provides an overview of the interaction between the system and the users in order to achieve the goal of developing the system. To ensure *WeightExpert* DSS runs smoothly, the identification of the system requirements in terms of operational facilities and system functionality is very crucial and essential.

Following by is system design which focuses on the activities involved in the process of designing the DSS framework. The system design process then translates the framework used for implementing the system into standard diagrams for implementation. The system design includes the compilation of data which is essential to assure the

production of a good system. Subsequently, the system is implemented according to the action plan prepared during the system design process. Description of the system implementation focuses on the activities involved for each stage throughout the system development process. In view of that, the system implementation process is seen to have a close relationship with the system design process of which both of these processes are very important procedures in developing a DSS. Once the system has been developed, testing process should be proceeded. System testing focuses on checking the interaction between user and the system. Testing was conducted to ensure the ability of each function to perform their tasks in the provided system, including examining the correctness of information accessing flow either from or to the user.

4.2 Data and System Analysis

An analysis of the system was conducted to identify the requirements needed by the system as described above. The purpose of carrying out the analysis on the data was to clarify the process that will be used to gather the scientific data. The architectural requirement was also conducted to identify the appropriate system architecture for developing the system and is explained in the system development process.

In this study, the foods and physical activities data were obtained from printed book and journal. The data in the reference sources is extracted and digitized into digital form and stored in the database. Data normalization is then performed to carry out the data cleaning process and a lot of effort had been put during this process. It is done to ensure the consistency of information between details stored in database and details resided in the original reference sources and there were no redundant data.

Two phases were carried out here; first, focusing on food data and second, focusing on physical activities data as described below.

(i) First phase: Digitization of food data and normalization comprising of 783 types of food

All food data were transferred into an Excel file before it was imported to the File Maker software. Then, they are sorted accordingly into 18 groups as listed in Table 4.1 below. Each food data was appended with 19 values of nutrient composition of edible portions (Figure 4.1).

Table 4.1: Food Data Classification

	Food Group	**Nutrient Composition**
1.	Cereals and grain	1. Energy 2. Water 3. Protein 4. Fat 5. CHO 6. Fibre 7. Ash 8. Ca 9. P 10. Fe 11. Na 12. K 13. Retinol 14. Carotenes 15. RE 16. B1 17. B2 18. Niacin 19. C
2.	Starchy root, tubers	
3.	Legumes	
4.	Nut, seeds	
5.	Vegetables	
6.	Fruits	
7.	Fish	
8.	Sugars and syrups	
9.	Meat	
10.	Fish and shellfish	
11.	Milk	
12.	Oil and fats	
13.	Beverages	
14.	Miscellaneous	
15.	Traditional Malaysian Kuih	
16.	Cooked dishes and meals	
17.	Franchised “Fast Foods”	

	Category	Name of Food	Serving size	Wt in household measure /as purchased (g)	Energy (kcal)	Water (g)	Protein(g)	Fat(g)	CHO(g)	Fibre (g)	Ash (g)	Ca (mg)	P(mg)	Fe(mg)	Na(mg)	K(mg)	Retinol (µg)
1																	
2	Null	Null	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Cereals and Grain	Barley,pearl (Beras Belanda);*Hordeum vulgare*	1 tablespoon	13	43	1.5	1.2	0.2	9.2	0.4	0.3	3	29	0.3	0	9	0
4	Cereals and Grain	Barley,pearl (Beras Belanda);Hordeum vulgare	1/4 cup	52	173	6.2	4.8	0.7	37.1	1.8	1.2	12	116	1.3	1	38	0
5	Cereals and Grain	Maize (Jagung);*Zea Mays*	1 tablespoon	14	49	1.8	1.3	0.6	9.5	0.3	0.2	6	31	0.4	2	10	0
6	Cereals and Grain	Maize (Jagung);*Zea Mays*	1 cup	222	789	30	20.4	10.2	153.9	4.4	3.1	100	498	6.4	24	169	0
7	Cereals and Grain	Corn Flour ;maize flour (Tepung Jagung)	1 tablespoon	8	29	1	0	0.1	6.9	0	0.1	1	13	0.1	1	2	0
8	Cereals and Grain	Maize (Jagung);*Zea Mays*	1 small packet	10	50	0.3	0.9	2.4	6.1	0	0.2	11	11	0.3	48	5	7
9	Cereals and Grain	Maize (Jagung);*Zea Mays*	1 medium packet	45	225	1.4	4.2	10.8	27.6	0	1	50	51	1.5	217	25	33
10	Cereals and Grain	Corn Snack,chicken flavoured (Snek jagung berperisa ayam)	1 small packet	18	91	0.7	1.1	4.6	11.2	0	0.4	3	9	0.5	127	8	9
11	Cereals and Grain	Corn Snack,chicken flavoured (Snek jagung berperisa ayam)	1 medium packet	45	227	1.7	2.8	11.5	27.9	0	1.1	6	23	1.2	316	21	22
	Cereals	Corn/rice snack,chicken	1 small packet	8	37	0.5	0.5	1.5	5.4	0	0.2	1	5	0.1	40	3	5

Figure 4.1: Digitization of food data and normalization

(ii) Second phase: Digitization of physical activities data and normalization comprising of 605 items

All physical activities data were transferred into an Excel file before it was imported to the File Maker software. After that, they were grouped into 22 different physical activity groups as listed in Table 4.2 below. Each of the physical activities was also matched with its respective value of exercise intensity measurement (MET) (formally known as a metabolic equivalent) as shown in Figure 4.2.

Table 4.2: Physical Activities Data Classification

	Physical Activities Group
1.	Bicycling
2.	Conditioning exercises
3.	Dancing
4.	Fishing and hunting
5.	Home activities
6.	Home repair
7.	Inactivity, quiet
8.	Inactivity, light
9.	Lawn and garden
10.	Miscellaneous
11.	Music playing
12.	Occupation
13.	Running
14.	Self-care
15.	Sexual activity
16.	Sports
17.	Transportation
18.	Walking
19.	Water activities
20.	Winter activities
21.	Religious activities
22.	Volunteer activities

1	Act categories	Activities Type	METS
8	Bicycling	bicycling, 14-15.9 mph, racing or leisure, fast, vigorous effort	10.0
9	Bicycling	bicycling, 16-19 mph, racing/not drafting or >19 mph draftingi very fast, racing general	12.0
10	Bicycling	bicycling, >20 mph, racing, not drafting	16.0
11	Bicycling	unicycling	5.0
12	Conditioning exercises	bicycling, stationary, general	7.0
13	Conditioning exercises	bicycling, stationary, 50 watts, very light effort	3.0
14	Conditioning exercises	bicycling, stationary, 100 watts, light effort	5.5
15	Conditioning exercises	bicycling, stationary, 150 watts, moderate effort	7.0
16	Conditioning exercises	bicycling, stationary, 200 watts, vigorous effort	10.5
17	Conditioning exercises	bicycling, stationary, 250 watts, very vigorous effort	12.5

Figure 4.2: Digitization of physical activities data and normalization

4.3 System Requirements

Analysis of system requirements in this study was conducted to determine and analyze the necessary prerequisite of the user and the system before undertaking the development process. Requirements on the system prototype are analyzed, including the functional and non-functional requirements. Functional requirements describe what needs to be done by identifying the specific tasks and activities while non-functional requirements are listed as the criteria required in an operational system.

4.3.1 User of the System

User requirements were defined through discussions and communications done with the experts in this field to gather the requirements for stakeholders. Through this informal discussion, they indirectly provide information on their needs and requirements that must be provided by the developed system. In addition, the study and observation on the existing systems were also performed to obtain input regarding the design models, procedures and problems encountered during developing the system. Through this study, the requirements regarding design and system development process are identified, including functional requirements and non-functional requirements. The system is tested by experts and also a public user. In this study, the developed system is targeted for the use of experts, health care providers, researchers and public users. An individual who is responsible on the system administration and management manages the system to ensure the system runs properly. The system is also managed according to the instructions and guidance from the experts, individuals who have the authority to the data and control the data allowed to be accessed.

4.3.2 Functional Requirements

The functional requirements are described by identifying what are the processes involved and how the system works to get the output when the user inserts an input. The functional requirements are also reviewed and are intended to manipulate the database whereas the requirement studies are focused on the interaction between users and functions available on the developed system. Functional requirements describe each function available in the *WeightExpert* DSS.

Here, workflows are used to illustrate the sequence of steps needed to reach its outcome. In this study, the system mainly consists of five workflows as listed and shown below:

i. Workflow of Respondent Management Module

User category: Expert, Admin

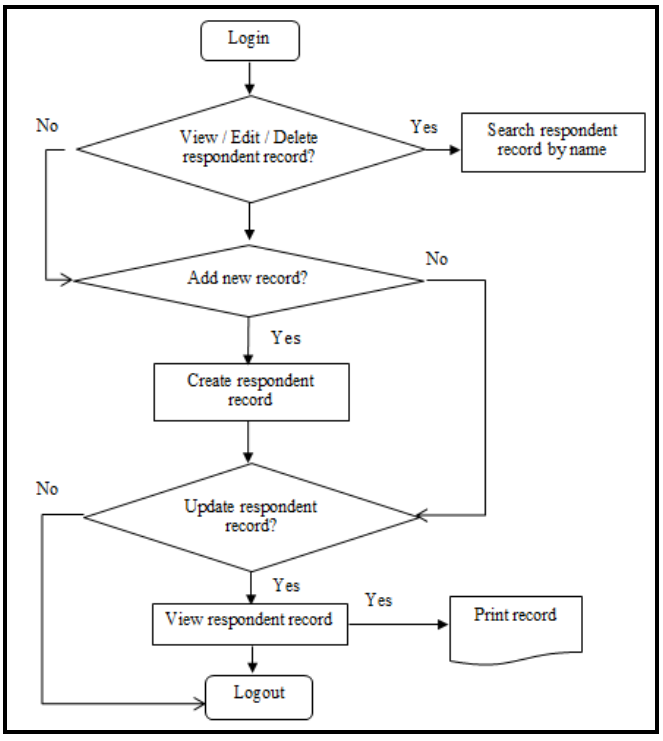


Figure 4.3: Work flow of Respondent Management Module

ii. Workflow of Weight Management Module

User category: Expert, Admin

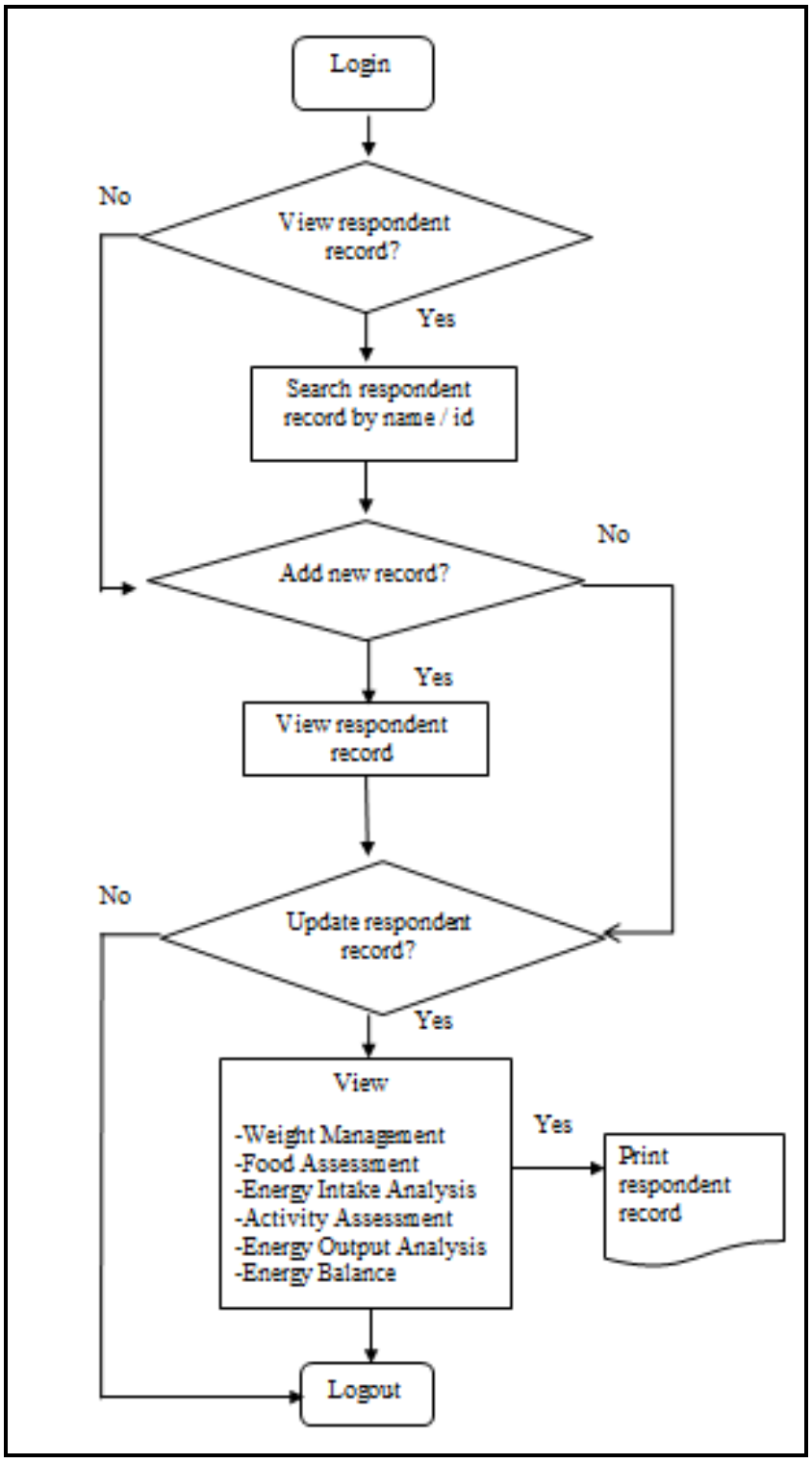


Figure 4.4: Work flow of Weight Management Module

iii. Workflow of Food Database Module

User category- Expert

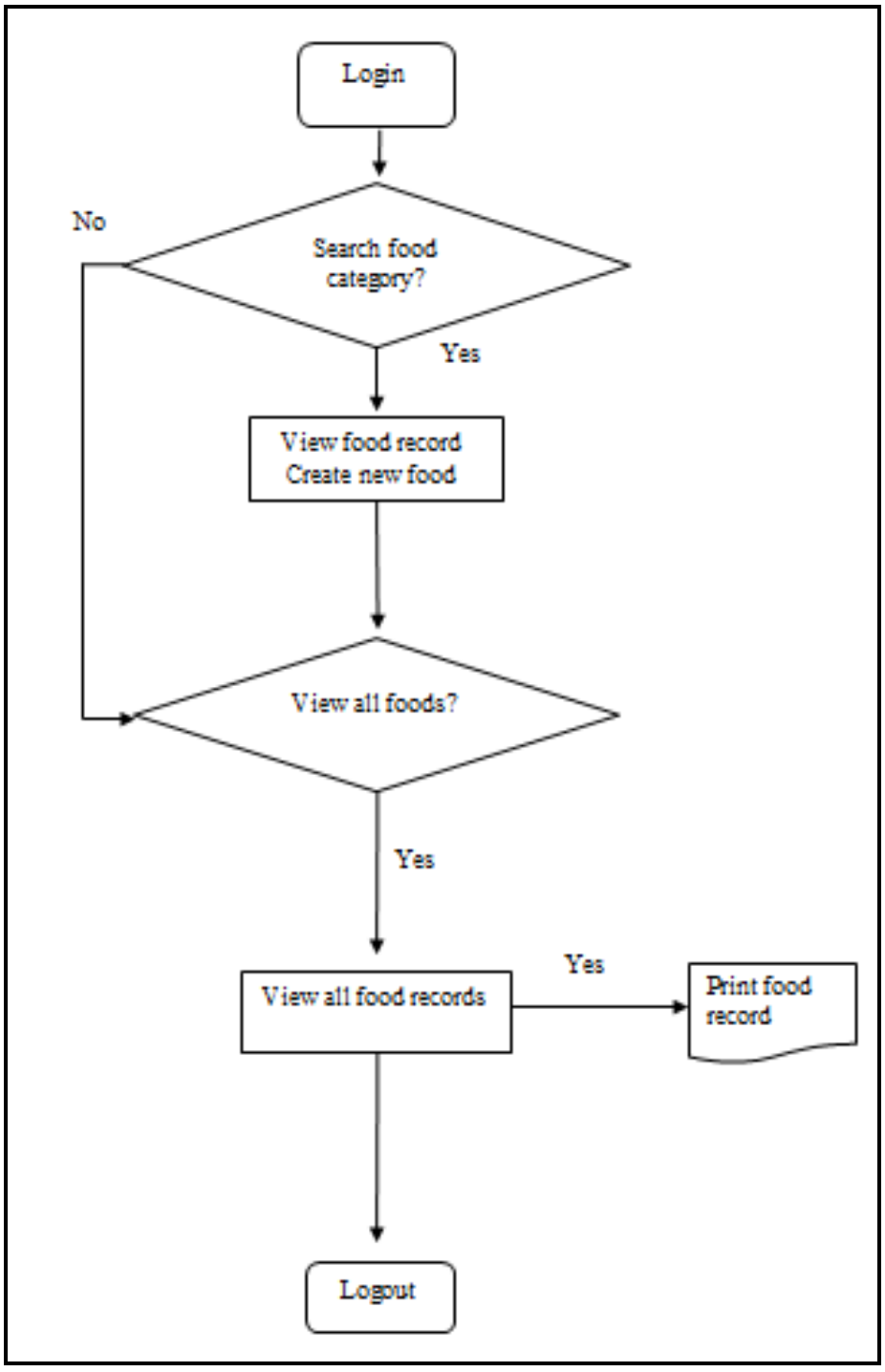


Figure 4.5: Work flow of Food Database Module (Expert)

Workflow of Food Database Module, continued

User category- Admin

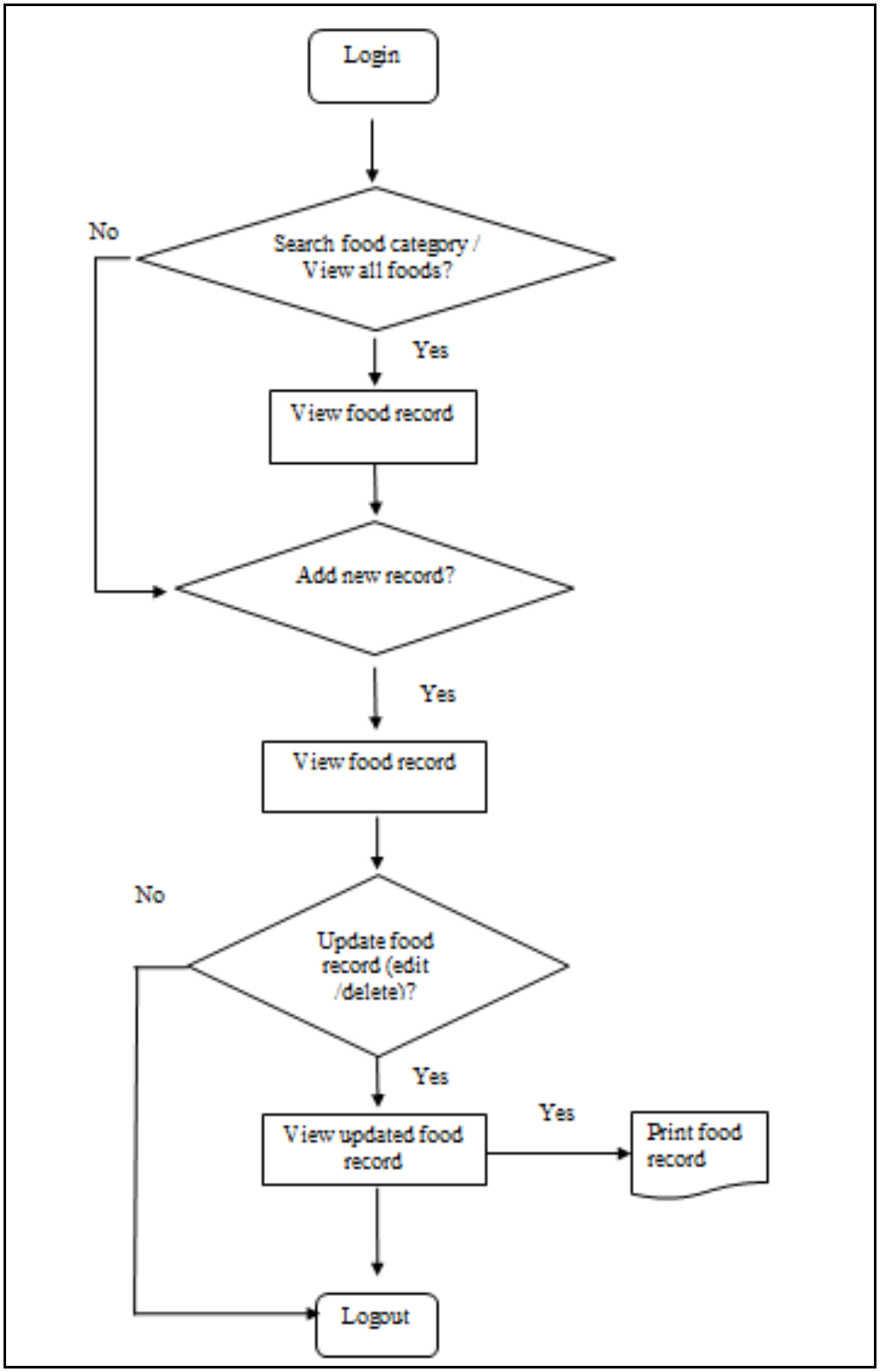


Figure 4.6: Work flow of Food Database Module (Admin)

iv. Workflow of Activity Database Module

User category- Expert

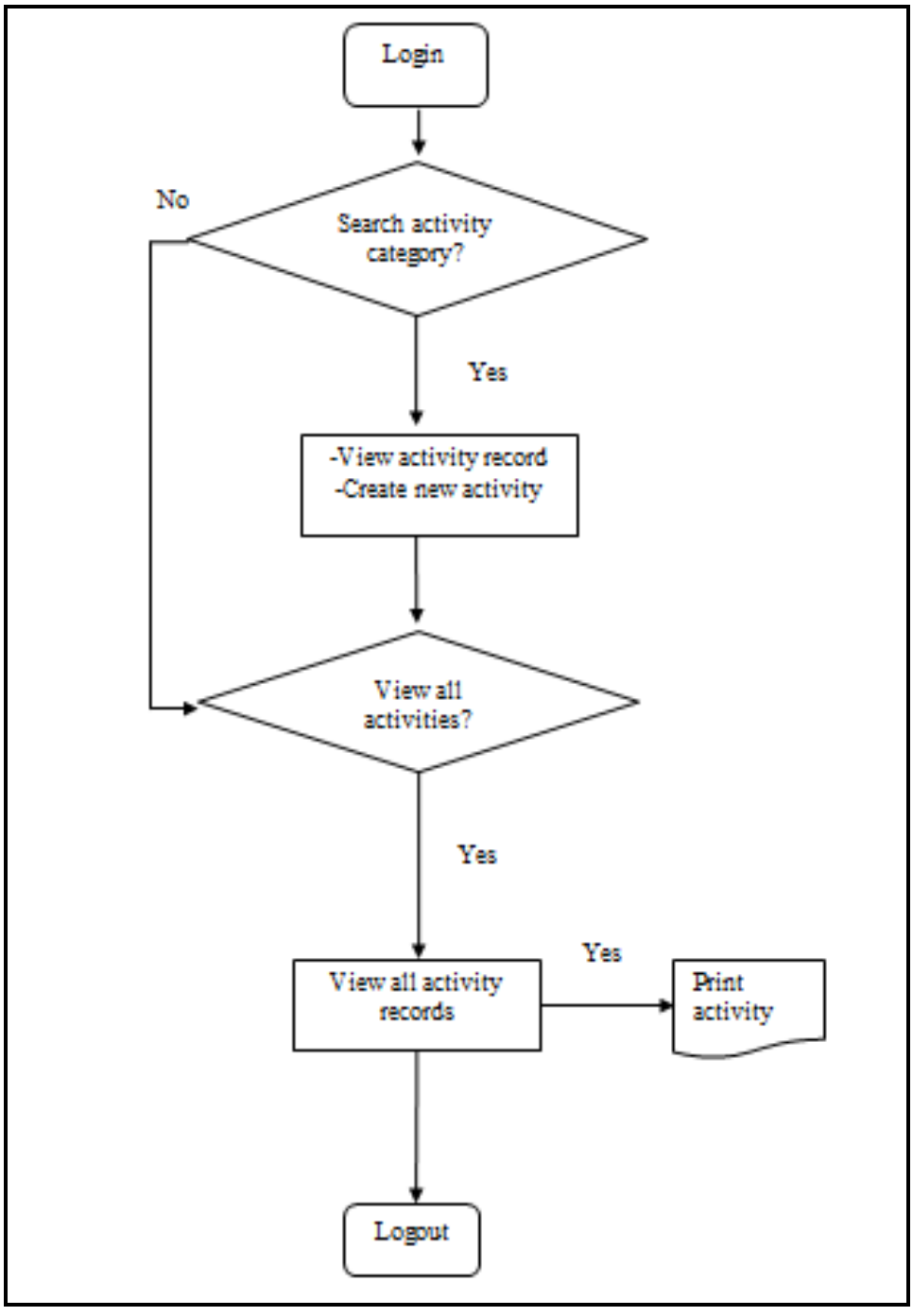


Figure 4.7: Work flow of Activity Database Module (Expert)

Workflow of Activity Database Module, continued

User category- Admin

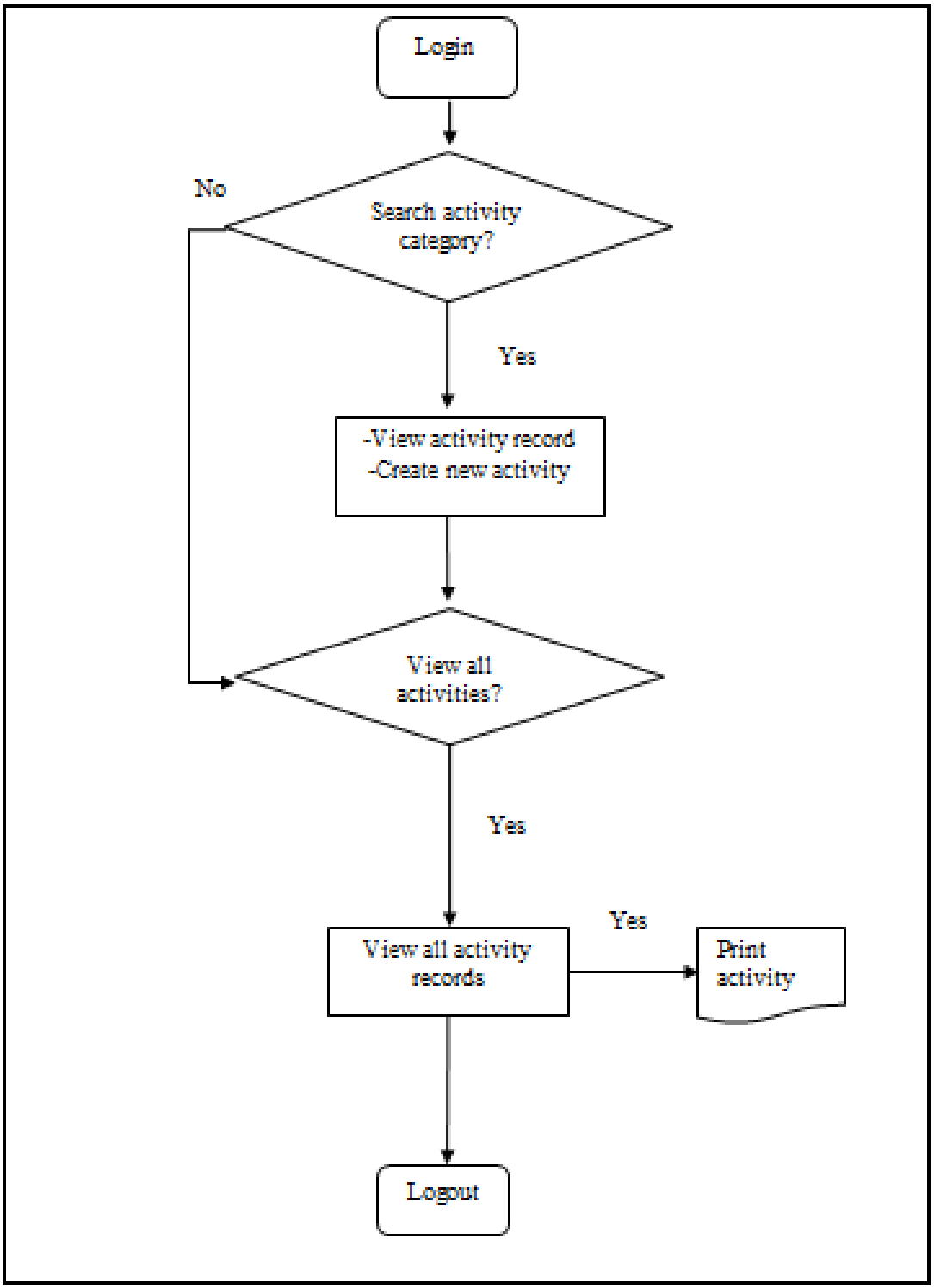


Figure 4.8: Work flow of Physical Activity Database Module (Admin)

4.3.3 Non-Functional Requirements

The non-functional requirements were studied from several different points of view and are usually classified according to a certain specific criteria. These criteria play a vital role in operating the system as these non-functional requirements are the additional requirements needed to optimize the *WeightExpert* DSS capabilities. In this study, the non-functional requirements should be reviewed prior to implementing the system design and the description encompasses on the functionality and manageability of the system. The descriptions on the non-functional requirements needed for *WeightExpert* DSS are described as follows:

(i) Usability of the system

A good system is a comprehensive system in terms of its information and ease of use. Therefore, *WeightExpert* DSS is developed with a bunch of useful and reliable data that can be utilized by the user which gives benefits to them. The display of this system is also arranged properly to facilitate user when browsing this database.

(ii) Data safety

The data collected and mainly used in this database are the researcher's property. Any misuse of this data by any irresponsible parties such as stealing data is an offense to be concerned with. *WeightExpert* DSS login system allows only certain accredited users who can access the entire data.

(iii) User friendly interface

A good system uses a simple approach for the user. *WeightExpert* DSS built a user friendly interface where it is provided in a simple and easy-to-understand format.

WeightExpert DSS applied a suitable background, font types and size as well as the proper interface layout structure. This is an important concern so that the system meets the ability of the users without the need for assistance when using the system.

(iv) Data manageability

The data maintenance requirement is needed in any developed system. *WeightExpert* DSS provides data managing functions where the addition or deletion of data, updating data, search, and data analysis can be done within this system.

4.4 System Design

In this phase, how the *WeightExpert* DSS will operate is decided, in terms of the hardware, software and user interface that will be used; and the specific programs, databases, and files that will be needed. Besides, two main parts in this design phase are logical design or known also as data modelling which encompasses data flow diagram (DFD) and entity relationship diagram (ERD). Details on the diagram as discussed below. Meanwhile, the interface design specifies how the users will move through the system in example navigation methods such as menus and on-screen buttons that the system will use.

4.4.1 *WeightExpert* DSS Data Flow Diagram (DFD)

The Data Flow Diagram is represented graphically which illustrates the movement of data between external entities and the processes and data stores within a system. DFD was built using the CASE Studio version 2.0 software for visualization of structured design data processing. At first, context level DFD was drawn to show the interaction between the system and the outer entities. The context level DFD was then expanded to

multi-level diagrams in order to further show the details of the system being modeled. All the DFD designed for *WeightExpert* DSS as listed in Figure 4.9.

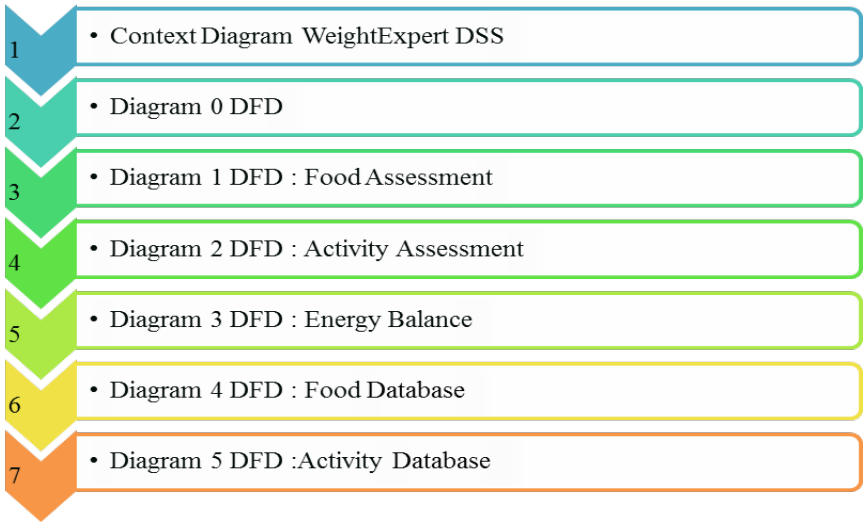


Figure 4.9: Data Flow Diagram (DFD) List

(i) Context Diagram of *WeightExpert* DSS

In *WeightExpert* DSS, there are four main components which are Expert, Energy Balance Calculator, Food Database and Activity Database where information comes from and goes to. For the public's use, they will have no access to the food database and the activity database.

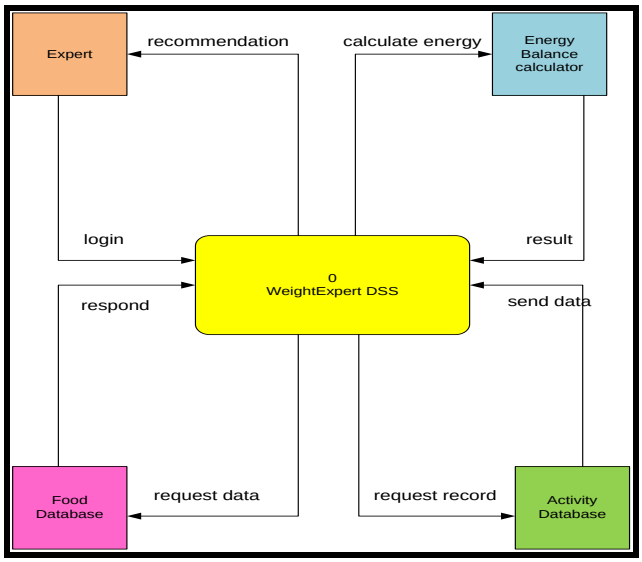


Figure 4.10: *WeightExpert* DSS Context Diagram

(ii) Diagram 0 DFD

In this DSS, there are five main processes that experts can execute which are:

i. Food Assessment

ii. Activity Assessment

iii. Energy Balance

iv. Food Search

v. Activity Search

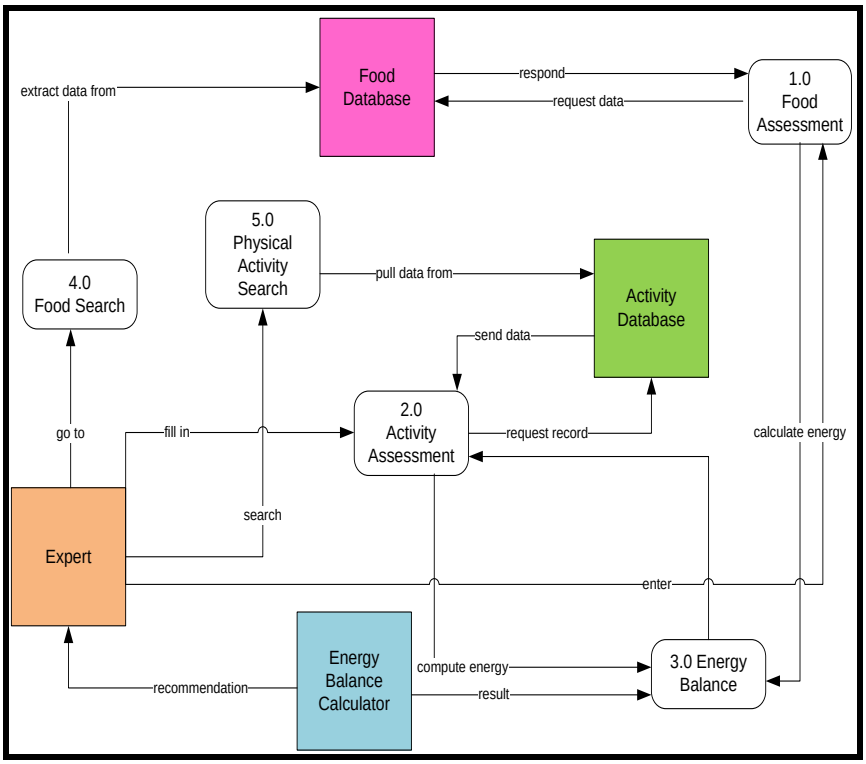


Figure 4.11: Diagram 0 DFD

(iii) Diagram 1 DFD: Food Assessment

The Food Assessment process includes Energy Intake Analysis. All food information that enters the system will be stored in a food record database.

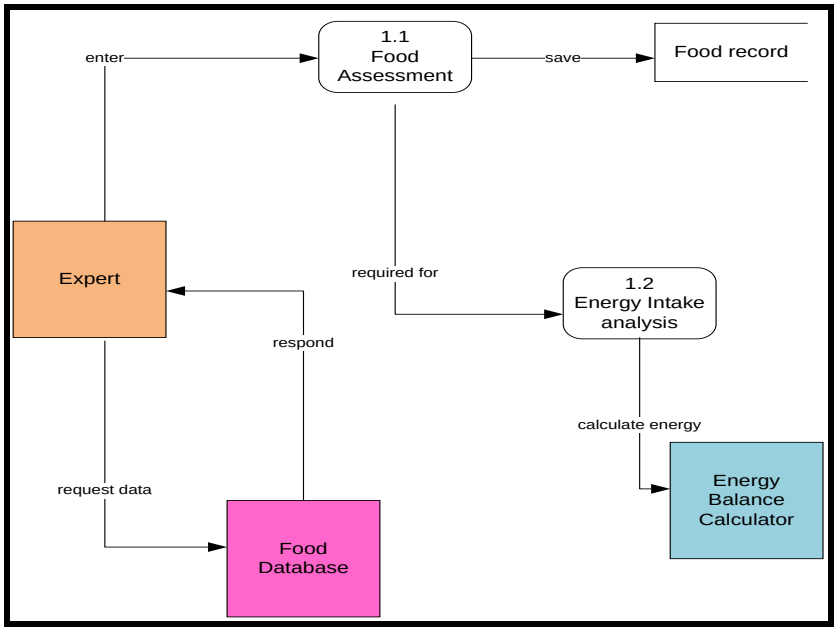


Figure 4.12: Diagram 1 DFD: Food Assessment

(iv) Diagram 2 DFD: Activity Assessment

The Activity Assessment process includes the Energy Output Analysis process for further analysis. All information related to the Activity Assessment that enters the system will be stored in an activity record database.

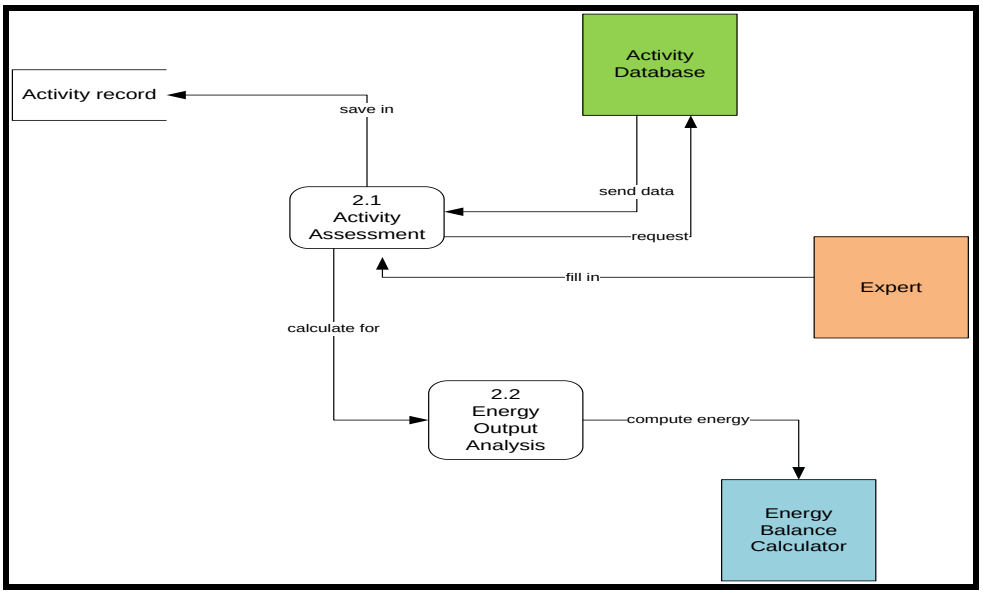


Figure 4.13: Diagram 2 DFD: Physical Activity Assessment

(v) Diagram 3 DFD : Energy Balance

The Energy Balance Assessment process summarizes calculation results from the Energy Input Analysis and the Energy Output Analysis.

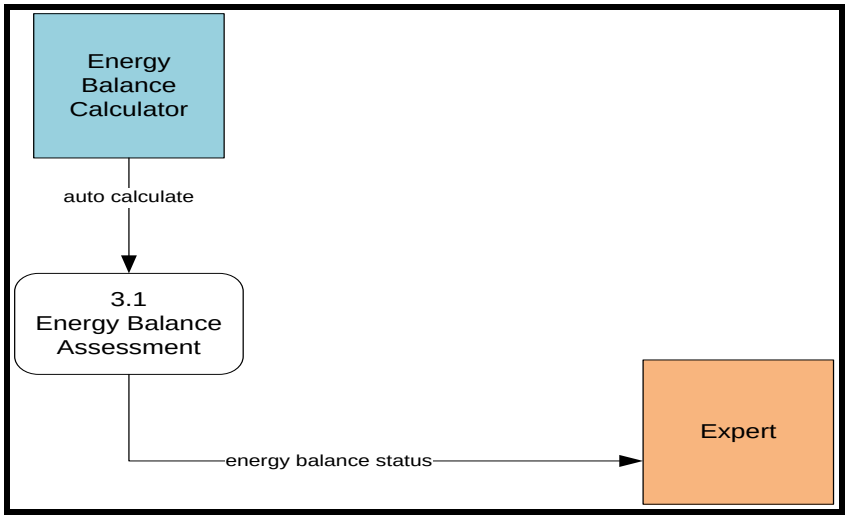


Figure 4.14: Diagram 3 DFD: Energy Balance

(vi) Diagram 4 DFD: Food Database

User category: Expert

Experts are only allowed to view food record and create new food record in the Food Database module.

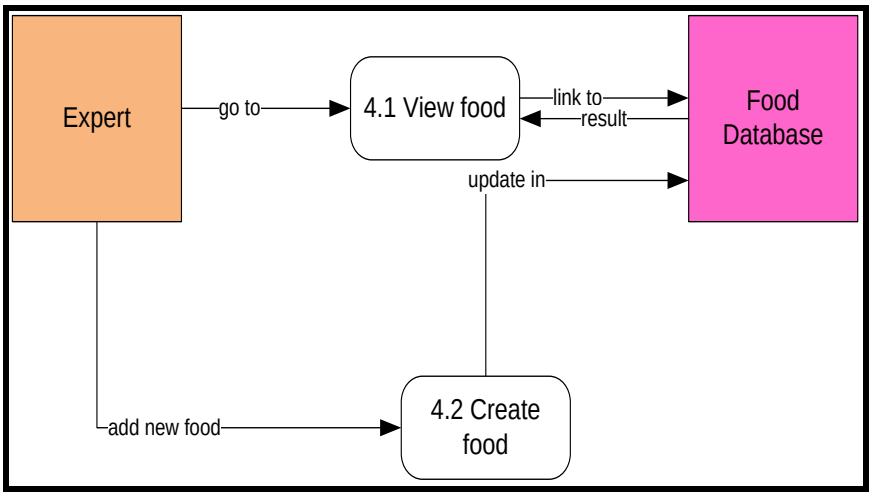


Figure 4.15: Diagram 4 DFD: Food Database (Expert)

User category: Admin

The Admin user category will have main authority in adding new food record, editing and even deleting existing food record in the Food Database module. Therefore, Experts are required to contact Admin for assistance in updating of any food-related information.

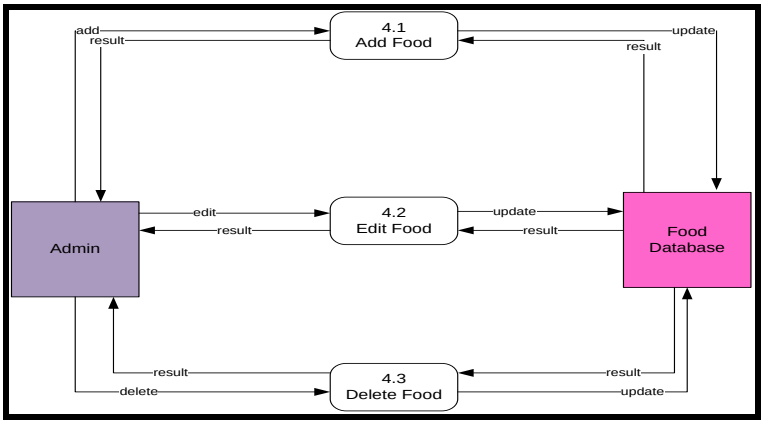


Figure 4.16: Diagram 4 DFD: Food Database (Admin)

(vii) Diagram 5 DFD : Activity Database

User category: Expert

Same goes to the Activity Database module, Experts are only allowed to view activity record and create new activity record while in this module.

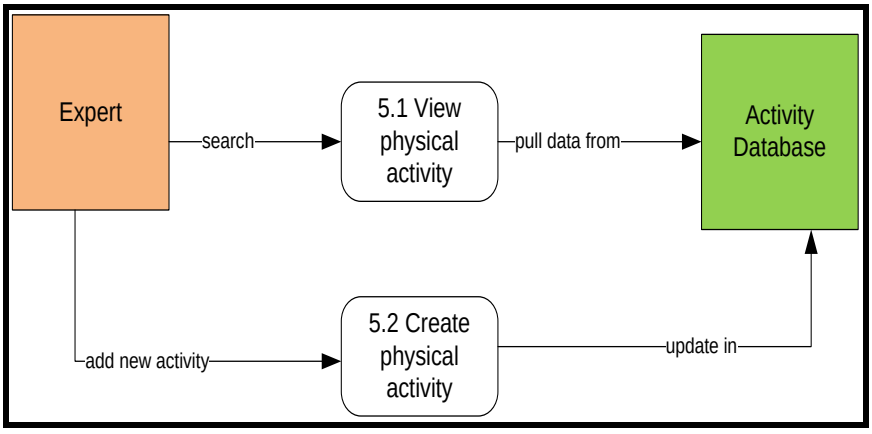


Figure 4.17: Diagram 5 DFD: Physical Activity Database (Expert)

User category: Admin

The Admin will have main authority in adding new activity record, editing and even deleting current activity record in the Activity Database module. Therefore, Experts are required to contact the Admin for assistance in updating of any activity-related information.

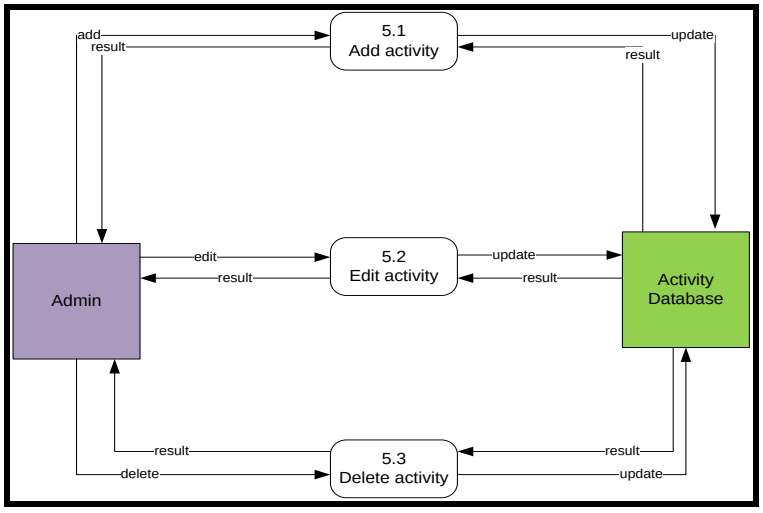


Figure 4.18: Diagram 5 DFD: Physical Activity Database (Admin)

Having a DFD makes the implementation easy because the end users are able to visualize the operation of the system, see a better perspective what the system could accomplish and how the whole project is implemented.

4.4.2 *WeightExpert* DSS Entity relationship diagram (ERD)

Next, an entity-relationship diagram (ERD) was created for a conceptual data model using the CASE Studio version 2.0 software. The ERD is also known as a conceptual representation of data structures that is required by a database. This model is very helpful in producing a solid database structure where it is able to store and retrieve data

efficiently. The ERD for this project can be seen below in Figure 4.19. Ten main entities of the system that support the development of the system are:

i. Respondent Info

ii. Weight history

iii. Food Intake

iv. Respondent Activity

v. Adult RNI

vi. Malaysian Dietary Guideline

vii. Food Database

viii. Food Database Value List

ix. Activity Database

x. Activity Database Value List

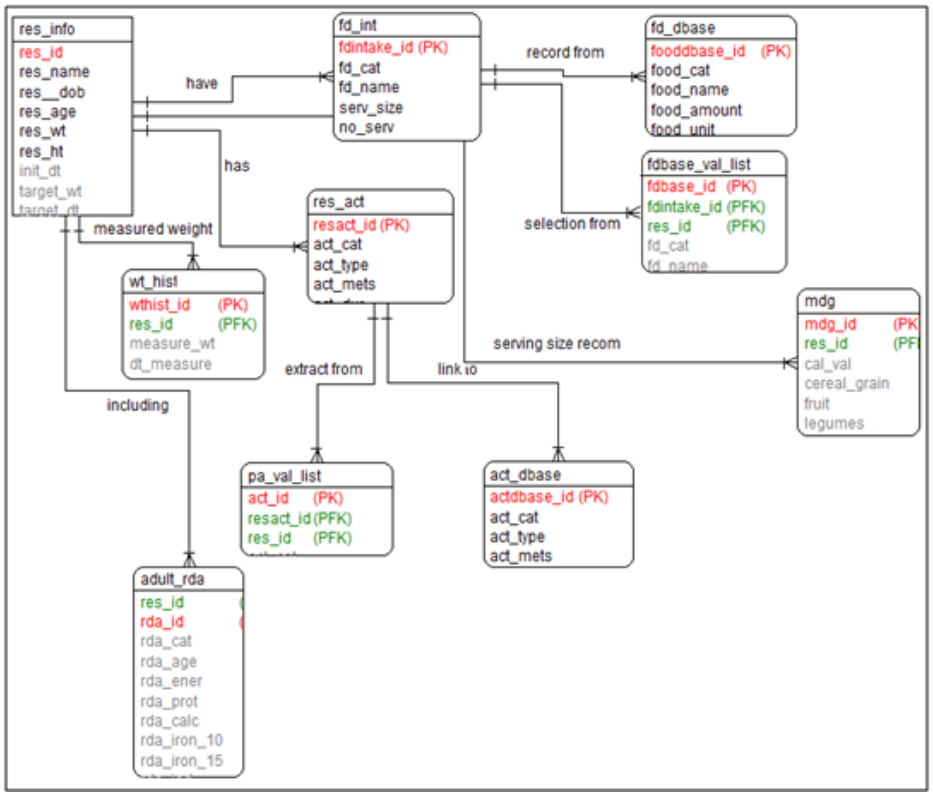


Figure 4.19: Entity Relationship Diagram (ERD)

4.4.3 User Interface Design

In this research, user interface design is created with the intention to describe the flow involved in the process of accessing the system. Interface designing task is executed to draw the outline of the visual representation of the system before it is being developed. One of the aims of designing the interface is to attract user to comfortably use the system and to provide a user-friendly system environment. Interface design serves to facilitate the process of developing the real system where every required function is placed in the suitable part on the system. The process of developing the system is already known to be based on the database design, yet it is also developed based on the interface design.

In *WeightExpert* DSS, the user is directed to the home page after logging into the system. From the home page, five modules are provided to access to the respective pages. The user interface design structure for *WeightExpert* DSS is shown in the following Figure 4.20.

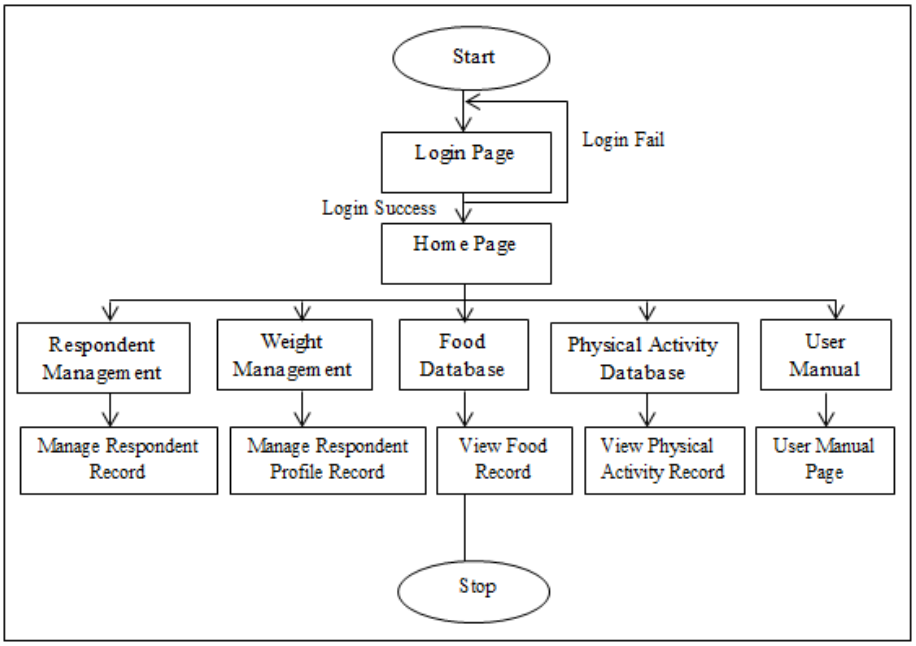


Figure 4.20: User interface design of *WeightExpert* DSS

4.4.4 Development Tools

In this study, some tools were used to develop *WeightExpert* DSS. The tools used consist of several hardware and software. The software used in developing this system is standalone software. Details on the hardware and software used throughout the system development process are shown in Table 4.3 below.

Table 4.3: Development tools used throughout *WeightExpert* DSS development

Development Tools	**Details**
Hardware Used	Intel(R) Core(TM)2 Duo CPU processor • 2 GB DDR2 • 120 GB HDD • 64-bit operating system • Resolution: 1280 x 800
Software Used	• Windows 7 Home Premium (Service Pack 1) • File Maker Pro 10 Advanced • CASE Studio version 2.0 • Microsoft Excel • Microsoft Office 2007 • Google Chrome

4.5 System Implementation

Following the system design phase is the system implementation phase. In this stage, logical models which have been designed during the previous phase were translated into physical models structure. The physical structure reflects the actual design of the system which is then transformed into database structure format. Once the data is prepared as described in the previous section, all the data is transferred and stored in the database. File Maker Pro 10 Advanced is used for developing DSS database. Table 4.4 below shows tables of data which is constructed according to the relationship diagram and briefly described the information provided from these tables. Basically, *WeightExpert* DSS has one database called as WeightExpert and it consists of eight tables. Metadata

and data definition is also described in the following Table 4.5 until Table 4.12. The process of developing user interface is the last process in the implementation phase. The user interface design which has been provided during system design phase is used as a guide in developing the interface for this system. User interface shows the process that occurs when accessing *WeightExpert* DSS starting from the home page to the other pages provided. The interface design of the *WeightExpert* DSS is available in Appendix A.

Table 4.4: Table Definitions for *WeightExpert* DSS

Table Name	Table Definition
res_info	Respondent personal information.
fd_int	Food intake for past 24 hour's information.
res_Act	Physical activity for past 24 hour's information.
wt_history	Respondent weight record.
mdg	Malaysian Dietary Guideline according to different calorie value.
adult_rni	Recommended Nutrient Intake according to different age group and sex group.
fd_dbase	Malaysian food database.
act_dbase	Physical activity database.

4.5.1 Database Metadata

Table 4.5: res_info metadata

Field	Type	Variable Description	Extra
res_id	text	Unique system-assigned ID (auto increment)	PK
res_name	Text (25)	Respondent full name	
res_dob	date	Respondent date of birth in the following format: DD-MM-YYYY	
res_age	calculation	Automated Respondent Age based on respondent date of birth	
res_cat	Text	Respondent category /gender to select: 1=Men 2=Women	
res_age_grp	Text	Respondent Age group to select: 1=19-29 years 2=30-50 years 3=51-59 years	

Table 4.5, continued

Field	Type	Variable Description	Extra
res_wt	Number (3)	Respondent weight in unit kg	
res_ht	Number (3)	Respondent height in unit m	
init_date	Date	Initial date of Respondent weight	
target_wt	Number (3)	Respondent weight target	
target_dt	Date	Target date for weight target	
wt_loss	Calculation	Respondent weight loss	
fd_cat	Text	Food category to select: 1=Beverages 2=Cereals and grains 3=Cooked dishes and meals 4=Eggs 5=Fish and shellfish 6=Franchised fast foods 7=Fruits 8=Legumes 9=Meat 10=Milk 11=Miscellaneous 12=Nuts, seeds 13=Oils and fats 14=Starchy roots, tubers 15=Sugars and syrups 16=Traditional Malaysian Kuih 17=Vegetables	
cal_int_percent	Calculation, Decimal (1)	Percentage of calorie intake from estimated energy requirement	
cal_exp_percent	Calculation, Decimal (1)	Percentage of calorie expend from estimated physical activity	
notes	Text (70)	Notes	
total_ener_int	Calculation	Total energy intake in unit kcal	
total_ener_expd	Calculation, Decimal (0)	Estimated Energy Requirement	
tot_prot	Calculation	Total of protein in unit kcal	
tot_cho	Calculation	Total of carbohydrate in unit kcal	
tot_fat	Calculation	Total of fat in unit kcal	
tot_cal_expend	Calculation, Decimal (2)	Total of calories expend from physical activity in unit kcal	

Table 4.6: fd_int metadata

Field	Type	Variable Description	Extra
fdintake_id	Text	Unique system-assigned ID (auto increment)	PK
meal_cat	Text	Meal category to select: 1=Breakfast 2=Morning Break 3=Lunch 4=Tea Time	

Table 4.6, continued

Field	Type	Variable Description	Extra
meal_cat	Text	Meal category to select: 5=Dinner 6=Supper	
fd_cat	Text	Food category to select: 1=Beverages 2=Cereals and grains 3=Cooked dishes and meals 4=Eggs 5=Fish and shellfish 6=Franchised fast foods 7=Fruits 8=Legumes 9=Meat 10=Milk 11=Miscellaneous 12=Nuts, seeds 13=Oils and fats 14=Starchy roots, tubers 15=Sugars and syrups 16=Traditional Malaysian Kuih 17=Vegetables	
fd_name	Text	Food name of each food category	
serv_size	Number	Serving size of each food	
serv_no	Number (2)	No of serving of each food that needs to be keyed in	
ener	Calculation	Energy in kcal	
prot	Calculation	Total of Protein in kcal	
cho	Calculation	Total of Carbohydrate in kcal	
fat	Calculation	Total of Fat in kcal	
res_id	Text	Respondent id	FK

Table 4.7: res_act metadata

Field	Type	Variable Description	Extra
resact_id	Text	Unique system-assigned ID (auto increment)	PK
act_cat	Text	Activity category to select : 1=Bicycling 2=Conditioning exercises 3=Dancing 4=Fishing and hunting 5=Home activities 6=Home repair 7=Inactivity, light 8= Inactivity, quiet 9=Lawn and garden 10=Miscellaneous	

Table 4.7, continued

Field	Type	Variable Description	Extra
act_cat	Text	11=Music playing 12=Occupation 13=Religious activities 14=Running 15=Self care 16=Sexual activities 17=Sports 18=Transportation 19=Volunteer activities 20=Walking 21=Water activities 22=Winter activities	
act_type	Text	Activity type of each activity category	
act_mets	Number	Metabolic equivalent measurement value of each activity	
hr	Text	Time to select for past 24 hours: 1=12 am 2=1 am 3=2 am 4=3 am 5=4 am 6=5 am 7=6 am 8=7 am 9=8 am 10=9 am 11=10 am 12=11 am 13=12 pm 14=1 pm 15=2 pm 16=3 pm 17=4 pm 18=5 pm 19=6 pm 20=7 pm 21=8 pm 22=9 pm 23=10 pm 24=11 pm	
min1	Text	Activity performed for first 15 minutes	
min2	Text	Activity performed for second 15 minutes	
min3	Text	Activity performed for third15 minutes	
min4	Text	Activity performed for fourth 15 minutes	
mets_min1	Number	First activity METs	
mets_min2	Number	Second activity METs	
mets_min3	Number	Third activity METs	
mets_min4	Number	Fourth activity METs	

Table 4.7, continued

Field	Type	Variable Description	Extra
tot_mets	Calculation	Total Metabolic equivalent of task (METs) of each activity	
act_dur	Number	Activity duration in minutes	
bmr	Calculation, Decimal (2)	Basal metabolic rate in kcal/day	
cal_exp	Calculation, Decimal (2)	Calorie expend for each activity /calorie burned for each activity	
res_id	Text	Respondent id	FK
act_id	Text	Activity id	FK

Table 4.8: wt_history metadata

Field	Type	Variable Description	Extra
wthist_id	Text	Unique system-assigned ID (auto increment)	PK
measured_wt	Number (3)	Respondent measured weight	
dt_measured	Date	Date for measured weight	
res_id	Text	Respondent id	FK

Table 4.9: mdg metadata

Field	Type	Variable Description	Extra
mdg_id	Text	Unique system-assigned ID (auto increment)	PK
cal_val	Number	Calorie value to select: 1=1500 2=2000 3=2500	
cereals_grain	Number	Recommended cereals and grains intake per day based on 30 g carbohydrate per serving and calorie value	
fruits	Number	Recommended fruits to be taken per day based on calorie value	
legumes	Number	Recommended legumes intake per day based on 7 g carbohydrate per serving and calorie value	
milk	Number	Recommended milk and dairy products intake per day based on 7 g carbohydrate per serving and calorie value	
fish	Number	Recommended fish products intake per day based on 14 g carbohydrate per serving and calorie value	
vege	Number	Recommended vegetable intake per day and based on calorie value	
meat	Number	Recommended meat / poultry intake per day based on 14 g carbohydrate per serving and calorie value	
res_id	Text	Respondent id	FK

Table 4.10: adult_rni metadata

Field	Type	Variable Description	Extra
rni_id	Text	Unique system-assigned ID (auto increment)	PK
rni_cat	Text	Recommended Dietary Allowances (RDA) category: 1=Men 2=Women	
age_grp	Text	Age group: 1=19-29 years 2=30-50 years 3=51-59 years	
prot	Number, Decimal (0)	Recommended protein intake per day in g	
calc	Number, Decimal (0)	Recommended calcium intake per day in mg	
iron_10	Number, Decimal (0)	Recommended Iron 10% bioavailability intake per day in mg	
iron_15	Number, Decimal (0)	Recommended Iron 15% bioavailability intake per day in mg	
iodine	Number, Decimal (0)	Recommended Iodine intake per day in µg	
zinc	Number, Decimal (1)	Recommended Zinc intake per day in mg	
selenium	Number, Decimal (0)	Recommended Selenium intake per day in µg	
thiamin	Number, Decimal (1)	Recommended Thiamin intake per day in mg	
riboflavin	Number, Decimal (1)	Recommended Riboflavin intake per day in mg	
niacin	Number, Decimal (0)	Recommended Niacin intake per day in mg NE	
folate	Number, Decimal (0)	Recommended Folate intake per day in µg	
vit_a	Number, Decimal (0)	Recommended Vitamin A intake per day in µg	
vit_d	Number, Decimal (0)	Recommended Vitamin D intake per day in µg	
vit_e	Number, Decimal (1)	Recommended Vitamin E intake per day in mg	

Table 4.11: fd_dbase metadata

Field	Type	Variable Description	Extra
fd_ cat	Text	Food category: 1=Beverages 2=Cereals and grains 3=Cooked dishes and meals 4=Eggs 5=Fish and shellfish 6=Franchised fast foods 7=Fruits 8=Legumes 9=Meat	

Table 4.11, continued

Field	Type	Variable Description	Extra
fd_ cat	Text	Food category: 10=Milk 11=Miscellaneous 12=Nuts, seeds 13=Oils and fats 14=Starchy roots, tubers 15=Sugars and syrups 16=Traditional Malaysian Kuih 17=Vegetables	
fd _name	Text	Food name of each food category	
serv _size	Number	Serving size of each food	
fd_wt	Number	Weight in household measure /as purchased in g	
fd_ ener	Number	Amount of energy content in foods is calculated from protein, carbohydrate and fat respectively in kilocalories(kcal);1 kcal =4.184 kJ	
fd _water	Number	Proximate Water composition in foods expressed in g	
fd_ prot	Number	Proximate Protein composition in foods expressed in g	
fd_ fat	Number	Proximate Fat composition in foods expressed in g	
fd_ carb	Number	Proximate Carbohydrate(CHO) composition in foods expressed in g	
fd_ fibre	Number	Proximate Fibre composition in foods expressed in g	
fd _ash	Number	Proximate Ash composition in foods expressed in g	
fd _ ca	Number	Proximate Calcium (Ca) composition in foods expressed in mg	
fd_ p	Number	Proximate Phosphorus (P) composition in foods expressed in µg	
fd_ k	Number	Proximate Potassium(K) composition in foods expressed in mg	
fd _retinol	Number	Proximate Retinol composition in foods expressed in µg	
fd_ carotenes	Number	Proximate Carotenes composition in foods expressed in µg	
fd_ re	Number	Proximate Retinol equivalents (RE) composition in foods expressed in µg	
fd_ b1	Number	Proximate Vitamin B1 (Thiamine) composition in foods expressed in mg	
fd_ b2	Number	Proximate Vitamin B2(Riboflavin) composition in foods expressed in mg	
fd_niacin	Number	Proximate niacin composition in foods expressed in mg	
fd_ c	Number	Proximate Vitamin C(Ascorbic acid) composition in foods expressed in mg	

Table 4.12: act_dbase metadata

Field	Type	Variable Description	Extra
act_id	Text	Unique system-assigned ID (auto increment)	PK
act_cat	Text	Activity category : 1=Bicycling 2=Conditioning exercises 3=Dancing 4=Fishing and hunting 5=Home activities 6=Home repair 7=Inactivity, light 8= Inactivity, quiet 9=Lawn and garden 10=Miscellaneous 11=Music playing 12=Occupation 13=Religious activities 14=Running 15=Self care 16=Sexual activities 17=Sports 18=Transportation 19=Volunteer activities 20=Walking 21=Water activities 22=Winter activities	
act_ type	Text	Activity type of each activity category	
act_ mets	Number	Metabolic equivalent of task (METs) of each activity	
act_ dur	Number	Activity duration in minutes	

4.5.2 *WeightExpert* DSS Calculation

The *WeightExpert* DSS shows the user the fields needed for data entry and includes factors needed for the automatic calculation of previously defined energy balance components, which is mainly based on energy intake and energy expenditure. Data entry fields that are required for the respondents to fill in are gender, height (in meters), age group, weight (in kilograms) and waist circumference (in centimeters). All of those

fields are compulsory to be keyed in in order to initiate the specific algorithm carried out by *WeightExpert* DSS.

To demonstrate the fields needed to be filled in by the user, an example is shown below in Figure 4.21 (using data from a participant; a man, 48 years old, height 1.65 meters, weight 90 kg and waist circumference 33 cm):

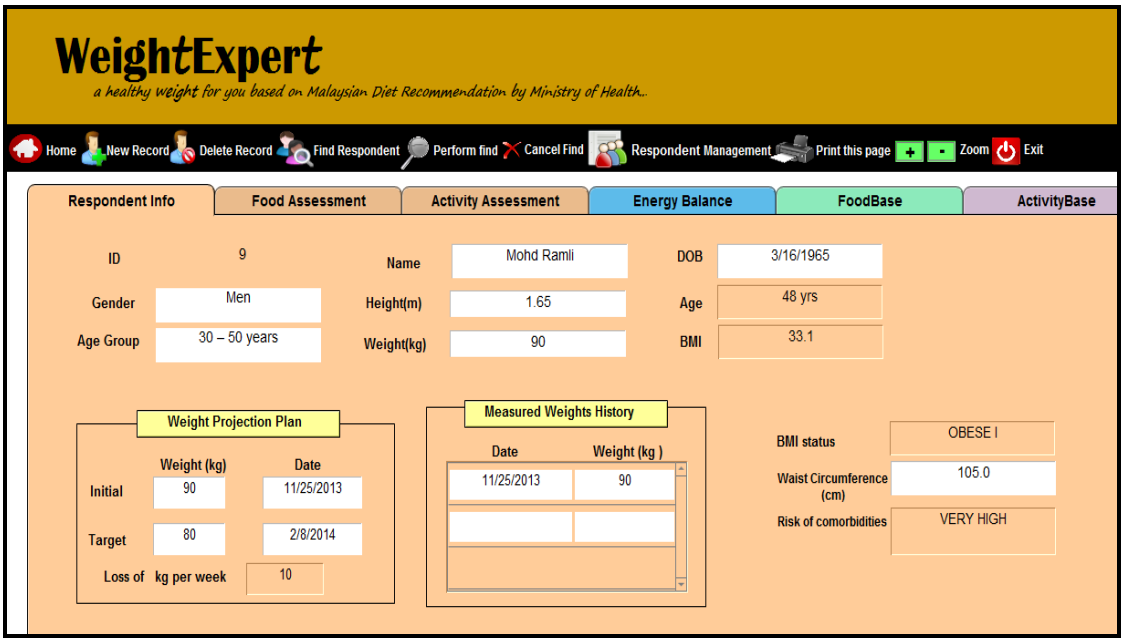


Figure 4.21: Sample of respondent record

4.4.1 How the calculation works

After the required data fields were entered, the *WeightExpert* DSS automatically calculates the Body Mass Index (BMI) and will display the BMI status and Risk of Comorbidity.

After that, the user has to insert food record that he/she has taken for the past 24 hours for *WeightExpert* DSS to perform food assessment and analysis. Users only have to enter the number of serving based on a serving size of each food type that has been

selected, and this application will automatically calculate the Energy (in kilocalories), Protein (in kilocalories), Carbohydrate (CHO) (in kilocalories) and Fat (in kilocalories).

For example, in Figure 4.22, if the respondent had fried kuih- teow with a serving size of 1 plate for his breakfast, the formula used to calculate the mentioned factors will be:

Food record: Fried kuih-teow, 1 plate

Protein (kcal): Number of serving x Protein (kcal) x 4 kcal=1 x 9.4 x 4 = 37.6 kcal

CHO (kcal): Number of serving x CHO (kcal) x 4 kcal = 1 x 36.2 x 4 = 144.8 kcal

Fat (kcal): Number of serving x Fat (kcal) x 9 kcal =1 x 15.5 x 9 = 139.5 kcal

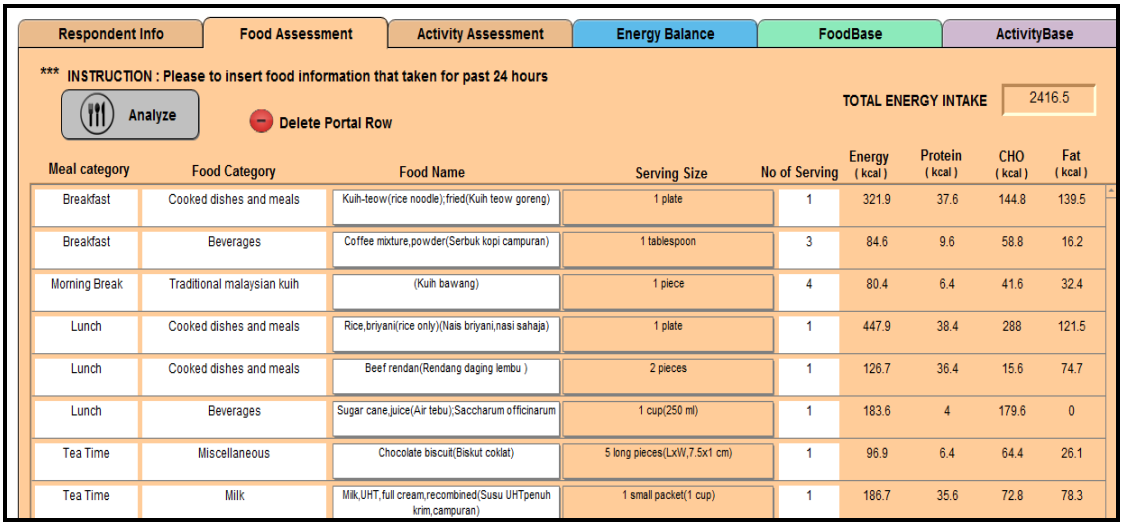
The above formula is needed to be applied here as the original value for Protein, CHO and fat per serving stored in the *WeightExpert* food database is in grams while Energy is in kilocalories. The value is 9.4, 36.2 and 15.5 respectively.

After that, *WeightExpert* DSS will automatically calculate the Energy of each food and Total Energy Intake from all the food record calculated.

The formula used for Energy is:

Energy (kcal) =Protein (kcal) + CHO (kcal) + Fat (kcal) =37.6+144.8+139.5 =321.9 kcal

The formula used for Total Energy Intake is sum of all energy in the food taken in kilocalories unit.



Meal category	Food Category	Food Name	Serving Size	No of Serving	Energy (kcal)	Protein (kcal)	CHO (kcal)	Fat (kcal)
Breakfast	Cooked dishes and meals	Kuih-teow(rice noodle),fried(Kuih teow goreng)	1 plate	1	321.9	37.6	144.8	139.5
Breakfast	Beverages	Coffee mixture,powder(Serbuk kopi campuran)	1 tablespoon	3	84.6	9.6	58.8	16.2
Morning Break	Traditional malaysian kuih	(Kuih bawang)	1 piece	4	80.4	6.4	41.6	32.4
Lunch	Cooked dishes and meals	Rice,briyani(rice only)(Nais briyani,nasi sahaja)	1 plate	1	447.9	38.4	288	121.5
Lunch	Cooked dishes and meals	Beef rendan(Rendang daging lembu)	2 pieces	1	126.7	36.4	15.6	74.7
Lunch	Beverages	Sugar cane,juice(Air tebu);Saccharum officinarum	1 cup(250 ml)	1	183.6	4	179.6	0
Tea Time	Miscellaneous	Chocolate biscuit(Biskut coklat)	5 long pieces(LxW,7.5x1 cm)	1	96.9	6.4	64.4	26.1
Tea Time	Milk	Milk,UHT,full cream,recombined(Susu UHTpenuh krim,campuran)	1 small packet(1 cup)	1	186.7	35.6	72.8	78.3

Figure 4.22: Food Assessment Sample

In energy input (EI) analysis (Figure 4.23), user can view i) Nutrient intake analysis; ii) Recommended serving size according to Malaysian Dietary Guidelines and iii) Recommended Nutrient Intake (RNI) according to age and gender.

Nutrient intake analysis is a summary of total energy, CHO, protein and fat from food consumption for the past 24 hours. The numbers of servings for the macronutrient intake were calculated based on 1500 kcal, 2000 kcal and 2500 kcal per day for each food group. RNI (MOH, 2005), meanwhile, is specifically designed for Malaysia and is according to specific range of age and gender.

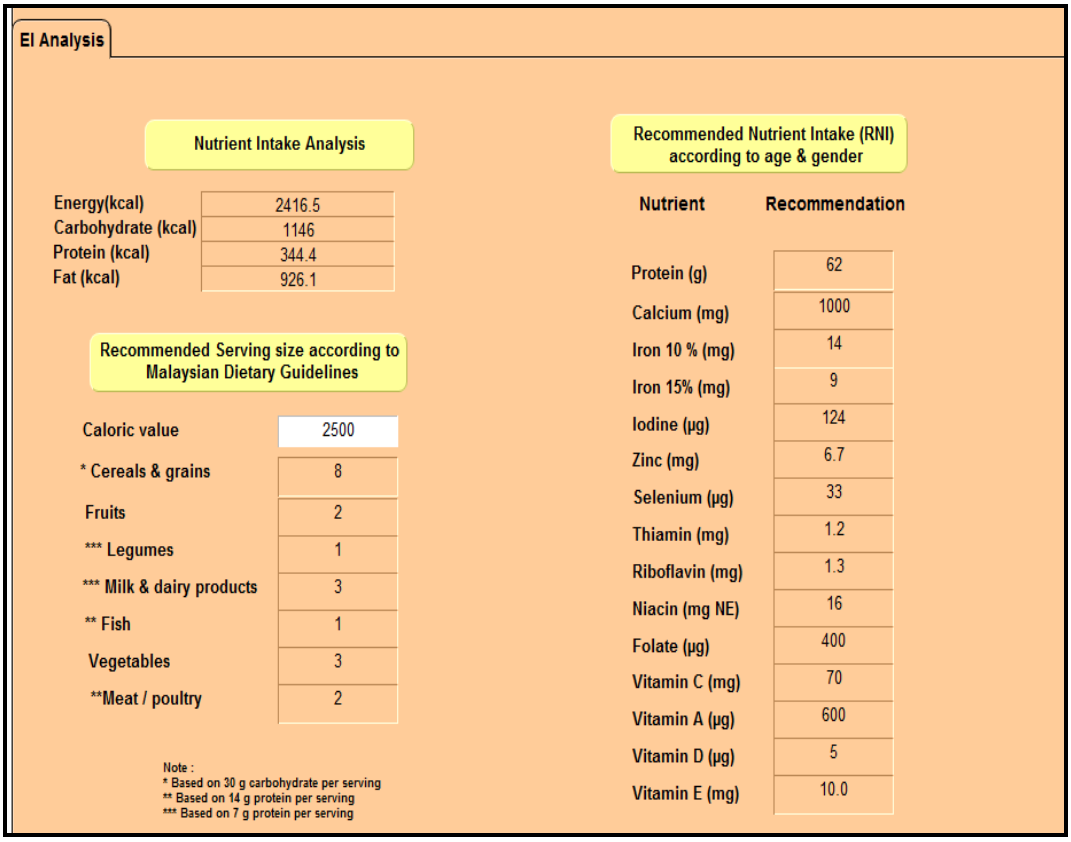


Figure 4.23: Nutrient Intake analysis

Next, the user has to insert information on activities performed for the past 24 hours for *WeightExpert* DSS to run calculations for calorie expend and analysis. The user has to key in activity done together with their METs value. *WeightExpert* DSS will then automatically calculate the calorie expend from those physical activities. For example, in Figure 4.24, let's say user enters reading for 24 hours as an activity, the formula used to calculate calorie expend is:

Physical activity: Reading; METs =1

Calories expended= Sum (METs * Weight (kg) * 0.25); 0.25 refer to 15 minutes/hour

= 4(1* 90 * 0.25) =90 kcal

Total calories expended = Sum (Calories Expended) =2160 kcal

The formula for BMR calculation is according to age and gender as shown in Table 4.13.

Table 4.13: Equation for BMR prediction for Malaysian adults (Ismail et al., 1998)

Age	Men	Women
18-30	[0.055 * Weight (kg) + 2.48] * 239	[0.0535 * Weight (kg)] + 1.994) * 239
30-60	[0 .0432 * Weight (kg) +3.112) * 239	[0.0539 * Weight (kg)] + 2.147) * 239

In energy output (EO) analysis (Figure 4.25), *WeightExpert* DSS will display the total estimated energy requirement based on moderate activity lifestyle and the average body weight of Malaysians are as reported by Lim et al. (2000). General guidelines used are:

Table 4.14: Energy requirements for adults (Lim et al., 2000)

Age	Men (kcal/day)	Women(kcal/day)
≤ 29	**2440**	**2000**
≤ 59	**2460**	**2180**

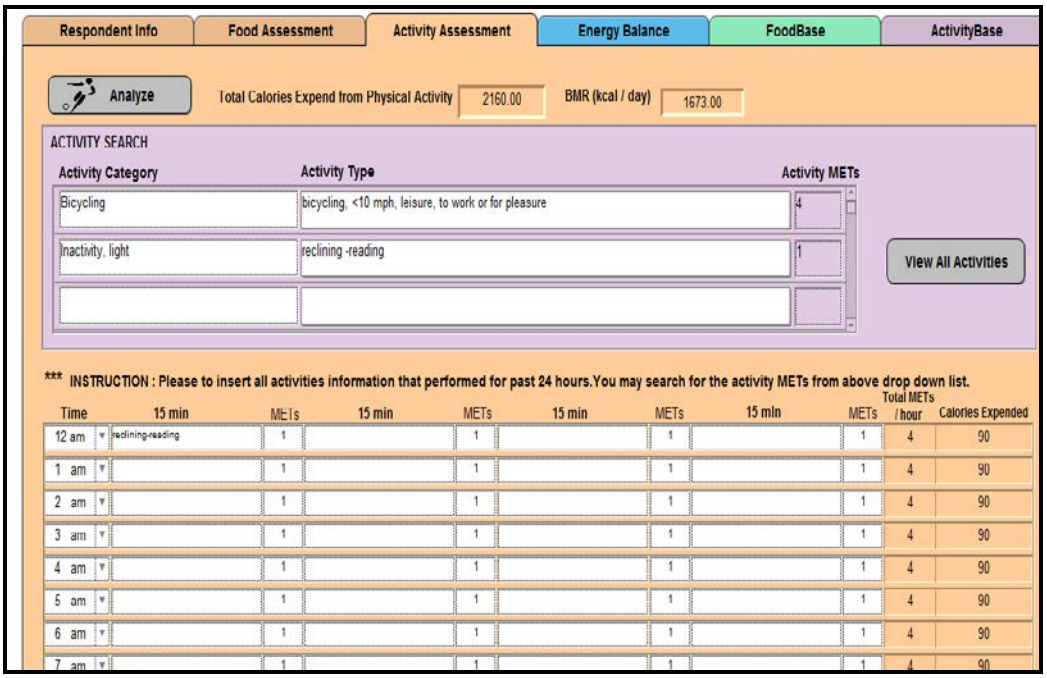


Figure 4.24: Physical Activity Assessment Sample

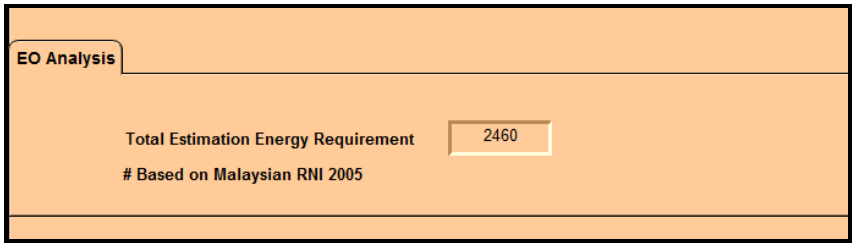


Figure 4.25: Energy output analysis

The final part will be the Energy balance module (Figure 4.26) whereby the user is able to view the recommended energy needed per day and compare it to the energy intake result as calculated. Here, user will know whether they have achieved energy balance or not.

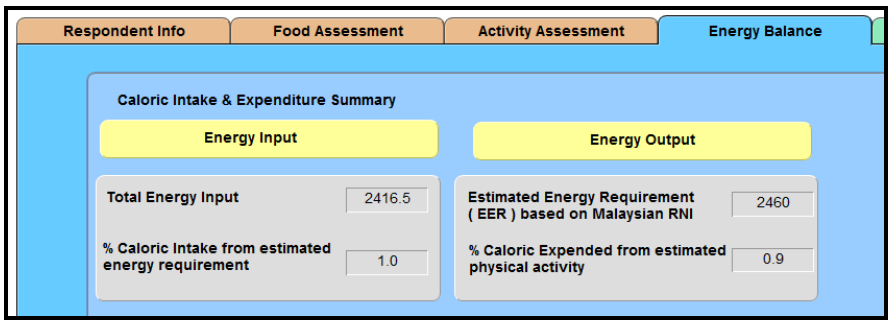


Figure 4.26: Energy Balance module

4.6 System Testing

System testing is the final procedure carried out in the *WeightExpert* DSS project. In this study, system testing was conducted to check the interaction process between users and the system. The users tested the ability of every function provided in the system to ensure each function is working in carrying out particular tasks without any problem. This process was accomplished by conducting a User Acceptance Test (UAT) with the experts to verify the functionalities and algorithm applied in the *WeightExpert* DSS. The system had been tested by thirty users comprising of experts and the public to gauge the

overall effectiveness of the prototype before it can be released for use. The feedback went a long way towards improving the DSS, to the end that a precise determination of energy intake, along with energy expenditure, was successfully achieved.

4.7 Summary

This chapter describes system design, system implementation, and system testing. These three aspects are very important in the development of any system. In this study, the system design process is viewed from three different categories; design of the system architecture, relational design and finally the user interfaces design. All the processes involved in system design phase should be done properly because they play an important role during the process of system implementation. Next, the chapter describes how the implementation process is executed. Here, it classifies the implementation process into three main parts: data preparation, database development and the last one is the user interface development. In sum, *WeightExpert* DSS that has been developed is tested through several test plans which aims to detect errors on the data or system functions.

CHAPTER 5

USER TESTING AND EVALUATION

5.1 Introduction

To meet the objectives of this project, user acceptance test created for expert to test and verify all functionalities and formula applied in the DSS before can proceed for the public user's access and evaluation. A usability study of the *WeightExpert* DSS prototype then was conducted online to measure the users' satisfaction and interaction with the DSS.

5.2 User Acceptance Test (UAT)

Below is the UAT script format used for testing and verifying of all the application functionalities and algorithms by the experts. It was divided into five main functionalities.

(i) Home page

Home screen					
Respondent Management Module, Weight Management Module, Food Database Module, Activity Database Module					
Objective	To validate Module functionality at Home page				
No	Item	Expected Result	Pass	Fail	Remark
1.	Login to prototype using the given Account name and password: Username : user Password : user13 Click OK button to login	Upon login in, user should be able to see Home page and four modules on the left: 1) Respondent Management 2) Weight Management 3) Food Database 4) Activity Database			
2.	Click Button 1,2,3	User should be able to read different information regarding system objectives			

(ii) Respondent Management Module

Respondent Management Module					
Respondent Search					
Objective	To validate all actions that can be executed in Respondent Management Module				
No	Item	Expected Result	Pass	Fail	Remark
1.	Click on Respondent Management	User should be able to see a list of Respondent records as below : 1) Respondent ID 2) Respondent name 3) Gender 4) DOB 5) Age 6) View / Edit Icon 7) Delete Icon			
2.	Click View /Edit icon	User will be navigated to Weight Management screen and be able to view or edit Respondent record			
3.	Click Delete icon	Respondent record will be removed from the WES. To confirm this action , the user can find the deleted record by performing Respondent Name search using Find Respondent			

(iii)Weight Management Module

Weight Management Module					
Respondent Info Tab, Food Assessment Tab, Activity Assessment Tab, Energy Balance Tab					
Objective	To validate all actions that can be executed for Energy Balance calculation				
No	Item	Expected Result	Pass	Fail	Remark
1.	Click on Weight Management	User will see three peach-colored Tabs : 1) Respondent Info 2) Food Assessment 5) Activity Assessment			
2.	Insert Respondent info in the Respondent Info tab. Compulsory information are as below: 1) Name 2) DOB 3) Gender: Men or Women 4) Height (m) 5) Age group: 19-29 years or 30-50 years or 51-59 years 6) Weight (kg)	All the information is automatically saved. User may add additional information in the Weight Projection Plan and Measured Weight History fields which are optional.			

Weight Management Module (continued)					
Respondent Info Tab, Food Assessment Tab, Activity Assessment Tab, Energy Balance Tab					
Objective	To validate all actions that can be executed for Energy Balance calculation				
No	Item	Expected Result	Pass	Fail	Remark
3.	Verify the BMI status after entering height and weight	The BMI will be based on BMI values as follows : Algorithm applied : bmi < 18.5;"UNDERWEIGHT"; bmi < 24.9;"NORMAL"; bmi ≤ 29.9;"PRE-OBESE"; bmi ≤34.9;"OBESE I"; bmi ≤ 39.9;"OBESE II"; bmi ≥ 40;"OBESE III";			
4.	Click on Food Assessment Tab. Then insert Respondent food information taken for the past 24 hours	User will see drop down list for meal category, food category and related food name for each category .After selecting food name, serving size will automatically be displayed. Automated calculation for Protein, CHO and Fat will be displayed after the user keys in number of serving. Formula applied : *Protein =No of serving x Protein x 4 kcal* *CHO = No of serving x CHO x 4 kcal* *Fat = No of serving x Fat x 9 kcal*			
5.	Verify Energy (kcal) for each food item input	Formula applied: *Total protein + Total CHO + Total fat*			
6.	Verify Total Energy Intake	Total Energy Intake will be displayed at the top, right Formula applied: *Sum of Energy (kcal)*			
7.	Set any existing record to Null value and then click delete portal row	System will delete the specified food record and Total Energy Intake will be updated automatically			
8.	Click Analyze button	System will navigate the user to the Energy Input(EI) analysis screen User should be able to see: 1-Nutrient Intake analysis result (should be similar to results in the Food Assessment Tab) 2-Recommended Nutrient Intake (RNI) 3-Malaysian Dietary guideline (MDG) for specified caloric value which are 1500, 2000 or 2500			

Weight Management Module (continued)					
Respondent Info Tab, Food Assessment Tab, Activity Assessment Tab, Energy Balance Tab					
Objective	To validate all actions that can be executed for Energy Balance calculation				
No	Item	Expected Result	Pass	Fail	Remark
9.	Click on Activity Assessment Tab. Then insert activity information done for the past 24 Hours	The user will see a purple box with the heading 'Activity Search'. Here, the user can search for activities by making a selection from Activity Category drop down list and then Activity Type drop down list. After selecting activity Type, Mets will be automatically displayed. The user may also view all activity detail by clicking on the View All Activities button. This functionality is specially added to assist the user to key in the activity information for Respondent in table below. The user will see a drop down list for Time .After selecting the time, the user will have to enter the activity that the respondent has done for the first 15 minutes from the selected time and METs value for that activity. This is followed by the next activity in the next 15 minutes, until the fourth set of 15 minutes. Automated calculation for calorie expend will be displayed after Total Mets is automatically calculated. Formula applied: *Sum (mets min * Respondent Info::Res wt * .25(15 minutes))*			
10.	Verify Total Calories expend from physical activity	Total Calories expend from physical activity will be displayed at top left Formula applied: *Sum of Calories Expended*			

Weight Management Module (continued)					
Respondent Info Tab, Food Assessment Tab, Activity Assessment Tab, Energy Balance Tab					
Objective	To validate all actions that can be executed for Energy Balance calculation				
No	Item	Expected Result	Pass	Fail	Remark
11.	Verify BMR (kcal/day)	BMR will be displayed at top centre Formula applied: Men *18-30:[0.055 x Weight (kg)+ 2.48] * 239* *30-60:[0 .0432 x Weight (kg)+ 3.112) * 239* Women *18-30:[0.0535 x Weight (kg)]+ 1.994) * 239* *30-60:[0.0539 x Weight (kg)]+ 2.147) * 239*			
12.	Click Analyze button	System will navigate the user to the Energy Output(EO) analysis screen The user should be able to see the Total Estimated Energy Requirement (EER) at the bottom of the screen Formula applied: Res Category = "Men" and Res age ≤ 29;2440; Res Category = "Men" and Res age ≤ 59;2460; Res Category = "Women" and Res age ≤ 29;2000; Res Category = "Women" and Res age≤ 59;2180; Above formula are based on Malaysian RNI 2005			
13.	Click on Energy Balance Tab (blue Tab)	System will display Caloric Intake and Expenditure Summary that consists of information such as: 1) Energy Input result • Total EI • % Caloric Intake from estimated energy requirement Formula applied: (Total Energy Intake / Total Energy Expenditure @ EER) 2) Energy Output result •Estimated Energy Requirement (EER) •% Calorie Expend from estimated physical activity Formula applied: (Total Calorie Expend from Physical Activity / Total Energy Expenditure @ EER) 3) Notes (optional field to fill in)			

Weight Management Module (continued)					
Respondent Info Tab, Food Assessment Tab, Activity Assessment Tab, Energy Balance Tab					
Objective	To validate all actions that can be executed for Energy Balance calculation				
No	Item	Expected Result	Pass	Fail	Remark
14.	Click Save as PDF button	User may save record in PDF format and specify location to save			
15.	Click Print All Pages button	User may print the record			

(iv)Food Database Module

Food Database Module					
FoodBase Tab					
Objective	To validate all actions that can be executed in Food Database Module				
No	Item	Expected Result	Pass	Fail	Remark
1.	Click FoodBase Tab	User will have two options to view food records: 1) View all foods record from database by clicking View All Food button 1) Select food category from Food category drop down list			
2.	Click View all food record	System will navigate the user to Food Database screen. The user should be able to view all the records in list mode and can use page up and page down to view the records. The user may add new food by clicking Create Food button.			
3.	Select food category from Food category drop down list	System will display only records from the selection			

(v) Physical Activity Database

Physical Activity Database Module					
ActivityBase Tab					
Objective	To validate all actions that can be executed in Activity Database Module				
No	Item	Expected Result	Pass	Fail	Remark
1.	Click ActivityBase Tab	User will have two options to view activity records: 1) Select activity category from Activity category drop down list 2) View all activities record from database by clicking View All Activities button			

Physical Activity Database Module (continued)					
ActivityBase Tab					
Objective	To validate all actions that can be executed in Activity Database Module				
No	Item	Expected Result	Pass	Fail	Remark
2.	Click View all activities record	System will navigate the user to Activity Database screen. The user should be able to view all the records in list mode and can use page up and page down to view the records. The user may add new activity by clicking Create Activity button.			
3.	Select activity category from Activity category drop down list	System will display only records from the selection			

Overall, expected result of functionalities testing were passed but only a few things need to be amended such as calories expended formula and BMR formula to use equations designed for Malaysians.

5.3 *WeightExpert* DSS Usability Study

A sample of thirty participants from different backgrounds was recruited to test the prototype. They consist of experts and public users and were invited to participate in the study via personal email. The experimental design was completely web-based and could be completed from the participant's home or workplace. A link to the experiment's web site was included in the recruitment email. The evaluation conducted focused on four components of data collection: (1) participant profiles; (2) participant interactions with the *WeightExpert* DSS prototype; (3) user satisfaction questionnaire; and (4) participant's response to three open-ended questions

Prior to answering the questionnaire, each participant was briefly explained about the overview of the prototype (Appendix B). They were then asked to complete a Profile Questionnaire in Section A (Appendix C) to describe their background including his/

her current level of Internet use and experience with any weight management application.

Following interaction with the *WeightExpert* DSS prototype, each participant was then asked to complete the Perceived Usefulness (Appendix D) in Section B of the questionnaire which measures the effectiveness of *WeightExpert* in relation to the experts' job. Participants also completed the User Interface and Satisfaction Questionnaire (Appendix E), which was based on the Questionnaire for User Interaction Satisfaction (QUIS), a tool developed at the Human-Computer Interaction Lab (HCIL), University of Maryland at College Park (About QUIS 7.0, 1998). Each section of the QUIS measures users' satisfaction with a specific aspect of the interface using a 7-point scale. QUIS allows configuration by including only the sections that are relevant to the particular study. This study utilized selected questions from five parts of the QUIS in Section C, which measures:

- Overall User Reactions to the *WeightExpert* - "satisfaction along five high level interface factors"
- Screen - "satisfaction with a number of factors related to visual displays"
- Terminology - "satisfaction with *WeightExpert* messages, user feedback, and task related wording that the *WeightExpert* generates"
- Learning - "user's perception of their ability to learn *WeightExpert* system tasks"
- *WeightExpert* Capabilities - "satisfaction with the *WeightExpert*'s performance and reliability, both in error recovery and error prevention"

After completing the User Interface and Satisfaction Questionnaire, participants were asked three open-ended questions to allow them to provide feedback in their own words. These questions can be found in Appendix E.

5.4 *WeightExpert* DSS Usability Study Results

The results from the usability study focused on four components of the study: (1) participant profiles; (2) participant interactions with the *WeightExpert* DSS prototype; (3) user satisfaction questionnaire data; and (4) participant responses to three open-ended questions

5.4.1 Participant Profiles

The group of participants included thirty individuals consisting of health professionals and members of the public. Using the Profile Questionnaire (Appendix C), basic information about the participants was collected. Eighteen women and twelve men participated with ages ranging from 19-29, 30-50 and 30-59 with participant classification as shown in Table 5.1. All participants had at least a college education. Level of computer skills using a 7-point scale, where 1 is strongly low and 7 is strongly high, showed twenty five participants (83%) rating their level of computer skills at a scale of 5 to 7 while five participants (17%) at a scale of 1 to 3. Thus, the participants as a whole are generally familiar with computers and the Internet. Twenty three participants (77%) indicated they had never seen such a prototype prior to this study, while seven participants (23%) indicated they had seen similar applications before. Seven participants (23%) were currently using other weight management application

programs such as MyFitness Pal, Herbalife and Nutritionist Pro for less than a year and three participants (10%) for 1 to 2 years.

Table 5.1: Participant Classification derived from Participant Profiles Questionnaire

Age	No of Participants	Participant Category
19-29	7	Student
30-50	19	Working Adult
51-59	4	Working Adult and Pensioner
Total of Participants	30	

5.4.2 Perceived Usefulness

This section was only targeting health professionals as it is interrelated to their job. Two participants (50%) out of four participants strongly agreed that by using *WeightExpert*, it would enable them to accomplish tasks more quickly, improve job performance, make their job easier and is useful to them. Two participants (50%) also completely agreed that *WeightExpert* would increase job productivity and enhance effectiveness.

Table 5.2: Experts Comment on DSS Perceived Usefulness

Name of Participants	Designation	Comment
Nur Syafawati bt Mohd Ghazali	Science Officer at Nutrition Department, Malaysian Ministry of Health	"Useful for health professional's use at first visit or specific planning program but have to allow find navigation for food record searching. To include more foods from other Asean food databases "
Syakirah bt Abu Bakar	Nutritionist at Kampar Clinic	"Simplifies work and save time on the energy calculation"

5.4.3 User Interface and Satisfaction Questionnaire

Following their interaction with the *WeightExpert*, each participant completed the User Interface and Satisfaction Questionnaire. The results are shown in Table 5.3; mean and standard deviation were calculated for each item in the questionnaire.

The midpoint of the rating scale (4) was used as a criterion. If the item had a mean above 4, it was perceived as being better than an arbitrary, mediocre value. All of the questions had a mean score above four. The questions with the lowest mean were:

- Question 14: Instruction for commands or functions is clear
- Question 15: Error messages popping out on the screen is helpful

Both of these questions had a mean of 5. The confidence interval around the mean for each of these two questions was calculated to determine its reliability. The 95% confidence interval for question 14 was equal to 5 ± 2.11, while the 95% confidence interval for question 15 was equal to 5 ± 1.47. The interval includes 4 within its boundaries, indicating that the mean is not significantly different from 4 at the 0.05 level of significance. Thus, the results suggest that the participants found the terminology used in the instructions to be ambiguous and the error messages popping out on the screen to be unhelpful, pointing to a need for improvement.

The questions with the highest mean were:

- Question 3: I am satisfied with the WeightExpert
- Question 4: The WeightExpert is adequately powerful
- Question 24:The WeightExpert is always reliable
- Question 25:Failure of the WeightExpert seldom occurrs

All these questions had a mean of 7.5. Thus, the User Satisfaction Questionnaire results suggest that the participants found that *WeightExpert* is adequately powerful, reliable, works very well and that they are satisfied with the application, revealing strengths that should be maintained in the final design of the *WeightExpert*.

Table 5.3: User Interface and Satisfaction Questionnaire Results

	Mean	Std Dev
Overall reactions to the WeightExpert		
1.The WeightExpert is wonderful	6	5.1
2.The WeightExpert is easy to use	6	5.1
3.I am satisfied with the WeightExpert	7.5	5.7
4.The WeightExpert is adequately powerful	7.5	5.2
5.The WeightExpert is flexible	6	4.5
Screen		
6.Items in the menu are well organized and functions are easy to find	6	3.6
7.I immediately understood the function of each item in the menu	6	3.3
8. All of the functions I expected to find in the menus are present	6	4.6
9. The buttons are well organized and easy to find	6	4.1
10. I immediately understood the function of each button	6	3.2
11.All of the functions I expected to find on the button bar were present	6	4.9
12. The usage of terminologies throughout the WeightExpert is consistent	6	5.6
13. Terminology used always relates well to the work you are doing	6	5.3
14. Instruction is clear	5	5.9
15. Error messages popping out on the screen is helpful	5	4.1
16. Performing an operation always leads to a predictable result	6	5.6
Learning		
17. Learning to use the WeightExpert is easy	6	5.3
18. Time taken to learn how to use the WeightExpert is short	6	3.9
19. Tasks can always be performed in a straightforward manner	6	5.8
20. Number of steps per task is just right	6	6.5
21. Steps to complete a task always follow a logical sequence	6	5.7

Table 5.3, continued

	Mean	Std Dev
WeightExpert Capabilities		
22. WeightExpert speed (to open or launch program) is fast enough	6	5.7
23. WeightExpert speed (to navigate within the system) is fast enough	6	4.4
24. The WeightExpert is always reliable	7.5	5.8
25. Failure in the WeightExpert seldom occurs	7.5	5.4

5.4.4 Participant's Response to the Open-ended Questions

After completing the User Satisfaction Questionnaire, participants were asked three open-ended questions to allow them to provide feedback in their own words. The first question was, “List the positive aspect(s) of the *WeightExpert* prototype”. The *WeightExpert* application is designed specifically to assist users in monitoring their calorie intake and energy output based on estimation of energy requirement per day by the Malaysia Ministry of Health (MOH, 2005). Thus, the first open-ended question gauges whether this aspect of the functionality is working and whether objectives of the study were achieved. All participants responded positively, satisfied with the practicality and design. Their comments are shown in Table 5.4.

Overall, the response to the first open-ended question suggests that the participants are aware of the appropriate methods to maintain a healthy weight and the importance of exercising regularly every day. These observations also describe strengths of the *WeightExpert* prototype that should be maintained in the final design.

Table 5.4: Open-Ended Question #1

Participant Comments: List the positive aspect(s) of the WeightExpert prototype
"Informative and easy to use."
"Educate on energy balance concept and it importance."
"Help to monitor calorie in and out daily."
"Able to self-monitor BMI from home."
"Useful for health professional's use at first visit or specific planning program."
"Easy to determine healthy weight range and have automatic calculation for calorie intake and calorie expend."
"Easy to use for all ages."
"Wide range of food selection."
"Can calculate the amount of calories/food/energy we consume from day to day."
"Easy to know / calculate calorie and exercise we required every day."
"Useful electronic application that can help keep track of food consumption and energy expenditure, since obesity is a huge problem."
"Comprehensive application for a weight management."
"Simplifies work and saves time"

The second open-ended question asked participants to comment on the most negative aspect(s) of the *WeightExpert* application. While twenty four of the participants (80%) found no negative aspects, the remaining participants (20%) provided negative comments, which indicate that there are improvements to be made to the *WeightExpert* prototype. Participant comments are shown in Table 5.5. All of the negative observations were related to functional aspects of the application design.

Table 5.5: Open-Ended Question #2

Participant Comments: List the negative aspect (s) of the WeightExpert prototype
“no daily record for the projected timeline”
“Being on a strict diet”
“no time to keep record in computer”
“Repeated food name such as coleslaw from Franchised Fast foods category”
“1.List of food limited 2.Difficult to search, consume times”
“The accessibility mechanism limited, consider extend to smartphone”

The third open-ended question asked participants to give suggestions to enhance or improve the *WeightExpert* application. Their comments are shown in Table 5.6. Most of the participants' commented positively on the functional features of the prototype and they what they liked most was the automated calculation provided by the application for body mass index (BMI) and calorie calculation. Two of the participants also suggested producing a more attractive interface using images or dynamic charts.

Table 5.6: Open-Ended Question #3

Participant Comments: Give your suggestion to enhance or improve WeightExpert prototype
“Provide variety of food records. Increase marketing and expose more to public.”
“to include daily record”
“run in smartphone”
“Short tutorial should be included for 1st timers”
“Make it more interactive”
“Make in bilingual ie Malay & English”
“Refine on food name ,maybe can put serving size after their name to differentiate repeated food name”

Table 5.6, continued

Participant Comments: Give your suggestion to enhance or improve WeightExpert prototype
"1. Add search criteria instead only select from drop down list option 2.To include Asian foods record from other countries like Singapore,Thailand and etc "
"make the design more interesting.can decorate or style it with pictures and take good control with the colours of every part. design is very important to attract people's interest.good job."
"Open for public access at clinic, hospital, shopping complex to educate the importance of a healthy body weight and monitoring it. Maybe can provide a kiosk machine or touch screen for public uses"

5.5 Summary

This activity was carried out to finalize the functional elements and algorithm applied in *WeightExpert* DSS by conducting a User Acceptance Test with the experts. The system has also been tested by thirty users comprising of experts and the public to gauge the overall effectiveness of the prototype before it can be released for use. The feedback went a long way towards improving the DSS, to the end that a precise determination of energy intake, along with energy expenditure, was successfully achieved.

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Discussion and Recommendations

The results from the usability study were intended to assist in the revision of the *WeightExpert* prototype. At the same time, it was conducted to prove the usefulness of the *WeightExpert* application to the experts and the public for healthy weight management. This investigation was limited to only a small group of participants for practical reasons and due to financial constraint, although the *WeightExpert* application aims to serve a wide range of users. As an extension to this study, the usability of the *WeightExpert* application should be tested with additional target groups, especially experts in government hospitals and private hospitals, to give a more complete representation of the users' needs. The study was also limited by the design of the test instrument. A future usability study may bring the participants on-site so that hands-on assessment can been done. An on-site study would also allow richer qualitative data to be collected through interviews and verbal reactions, instead of relying on participants to supply comments to open-ended questions on a web-based form. The main advantage of the test instrument used in this study was that it allowed participants to explore the *WeightExpert* application in a familiar environment, without the pressure of a study proctor observing their every movement.

Given its strengths and limitations, the study was supported by the collection of data that generated some useful results. Participants' response highlighted the importance of flexibility of access and variety of food and physical activity options. These findings

will be used to improve the *WeightExpert* application so that it fulfills its goals to provide a comprehensive weight management DSS for Malaysian adults.

The results show that participants' reactions to the *WeightExpert* prototype were generally positive. All of the questions on the User Satisfaction Questionnaire received an average rating above 5, on a scale from 1 to 7 where positive adjectives anchor the right end of the scale and negative adjectives anchor the left. Participants confirmed these useful features of the system:

- They liked the automated calculation for Body mass index (BMI), calorie intake and calorie expenditure.
- They commented that the prototype was adequately powerful, straightforward and easy to use.
- They found the interface to be well- structured and well designed.

The study did identify some areas where the quality and overall usability of the *WeightExpert* application can be improved and they are:

1) Make available as a web-based application, seeing it can run online. The system will store values for such volatile attributes as weight, food intake records, physical activity records, total energy intake and total energy expenditure periodically in a local database. Most importantly, this system allows the capture, processing, storage and transmission of sensitive data such as weight record for immediate and recurrent use.
2) Have distinct layout designs for mobile application to support new technologies such as Iphone and Ipad that allow users to install the application on the mobile device. It is also for easy user access and to optimize the application for daily use.

3) To include food categories based on different ethnics; Malay, Indian and Chinese. Food records and options for physical activities should be updated to be more varied. Additional information such as nutrient composition in fatty foods, fast foods and alcohol should also be added.
4) Improve the presentation of data in the application by using real-time graphs or dynamic charts to boost user engagement and can also be used as an educational tool.
5) To include user manual in the system for application guideline.
6) To provide application in Malay version as well.

6.2 Conclusion

Due to the increase of weight problems among adults and a need for comprehensive information on actual dietary intake, the *WeightExpert* System developed may lead to better data analysis and decision-making for experts (nutritionists and dietitians) that may encompass recommended dietary allowance and physical activity recommendations.

The public would also be served well by becoming more knowledgeable about evidence based guidelines, scientifically-proven and medically-safe standards that underlie national public health policies. When more people know what's important and realistic in achieving and maintaining a healthy body weight, fewer will be inclined to waste their money, time, and effort on dangerous fads or miracle cures. Furthermore, almost all weight-loss experts agree that the key to long-term weight management lies in permanent lifestyle changes that include, among other things, a nutritious diet at a moderate caloric level and regular physical exercise.

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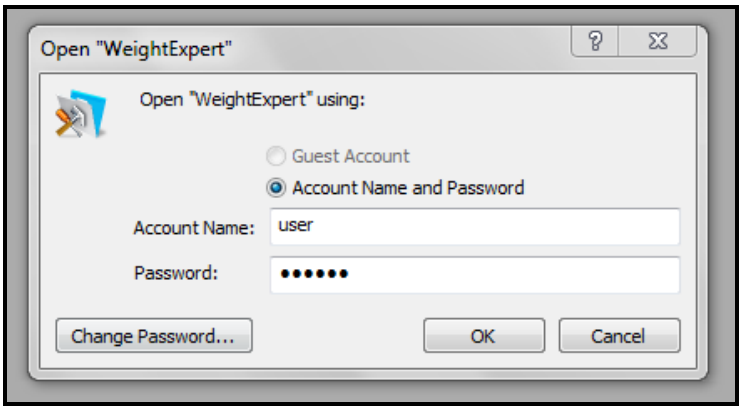
Appendix A: Screen Shots of the *WeightExpert* DSS

(i) Login screen



(ii) Home page

Description of main modules at Home Screen

No	Modules	Description
1.	Respondent Management	To manage respondent record including actions as following: 1- Search respondent record 2-View respondent record 3-Edit respondent record 4-Delete respondent record
2.	Weight Management	To assist in managing respondent's weight at a healthy level by entering specific information needed for Energy Balance calculation and analysis. All information regarding food and activities that the User keys in must be from the past 24 hours. Sub modules for this module are: 1- Respondent Info 2- Food Assessment 3- Physical Activity Assessment 4- Energy Balance

Description of main modules at Home Screen, continued

No	Modules	Description
3.	FoodBase	Enables the user to view all food records consisting of 1605 food items with 19 nutrient composition information for each food item
4.	ActivityBase	Enables the user to view all records regarding activities consisting of 605 activities with their metabolic equivalent (Mets) value

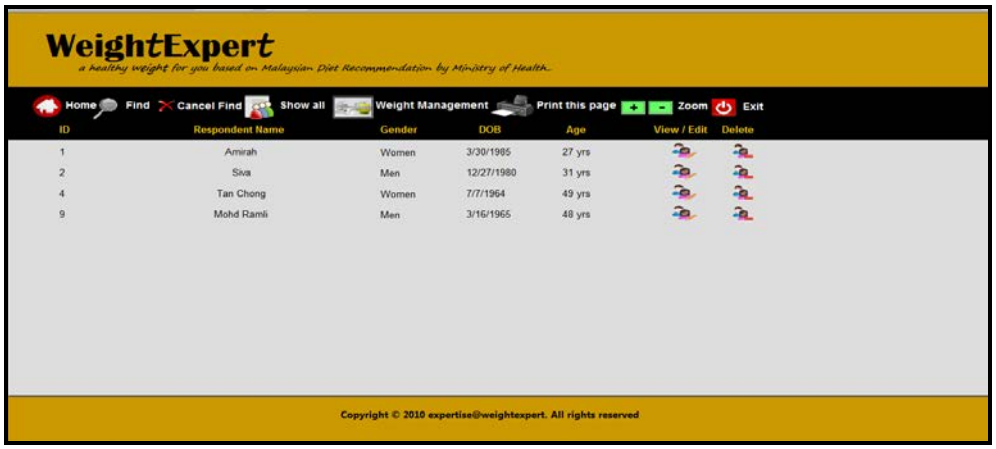
WeightExpert DSS button features

No	Button	Description
1.		Go to Home screen
2.		Perform find / Enter Find mode
3.		Cancel find
4.		Show all respondent record in list mode
5.		Go to Weight Management screen
6.		Add new respondent record
7.		Delete respondent record
8.		Create Food record
9.		Create Activity
10.		Page down
11.		Page up

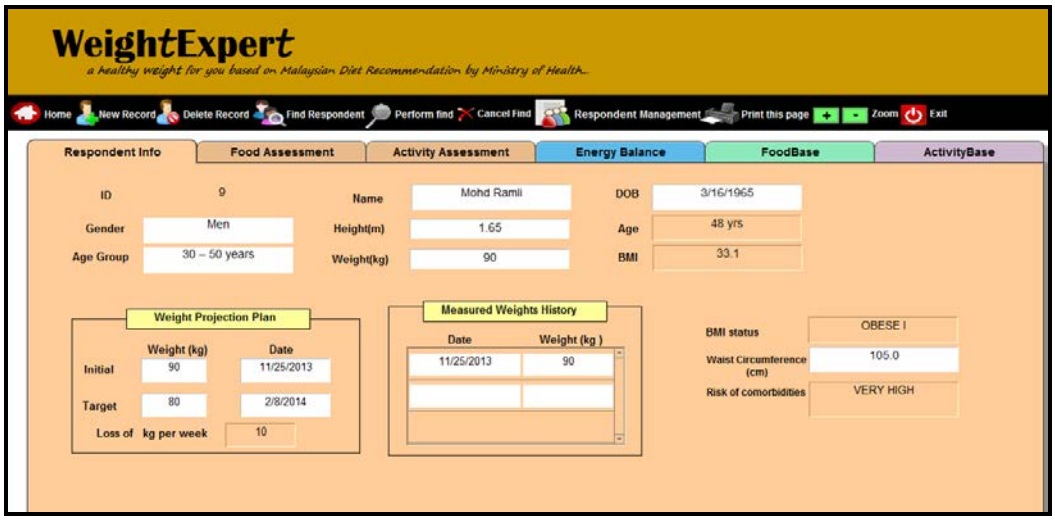
WeightExpert DSS button features (continued)

No	Button	Description
12.		Next page
13.		Previous page
14.		Delete record in portal row. Note: To delete the record must make selection to null
15.		Print
16.		Find specific respondent record
17.		Edit Respondent Information
18.		Delete Respondent Information from WES
19.		Zoom in
20.		Zoom out
21.		Exit application

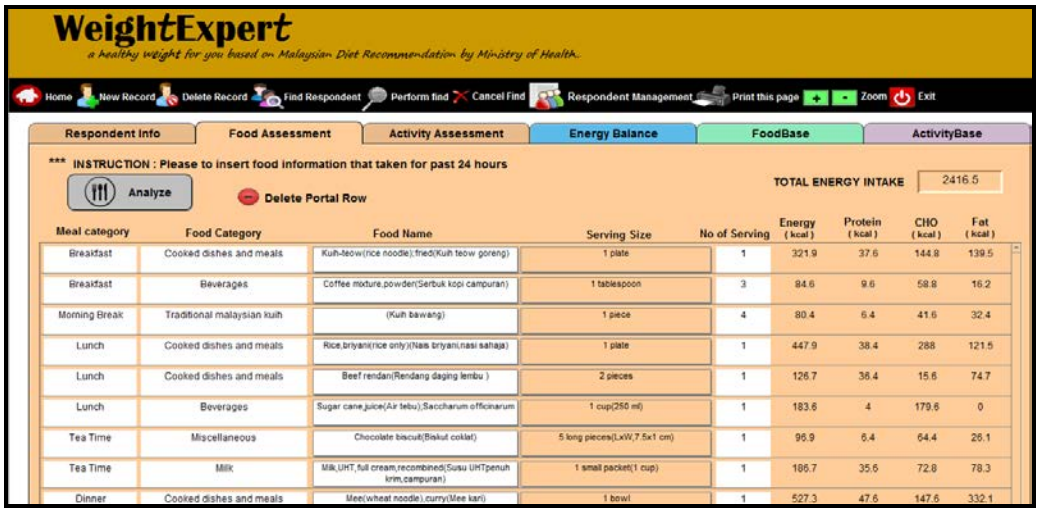
(iii) Respondent Management screen



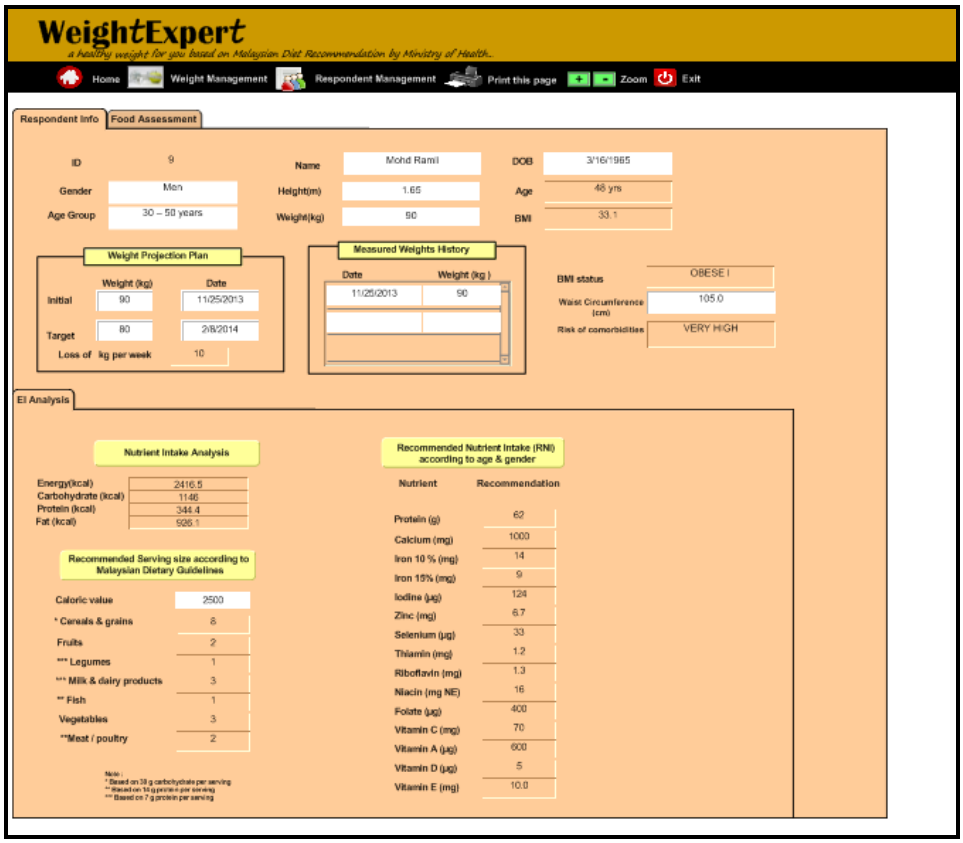
(iv)Weight Management screen



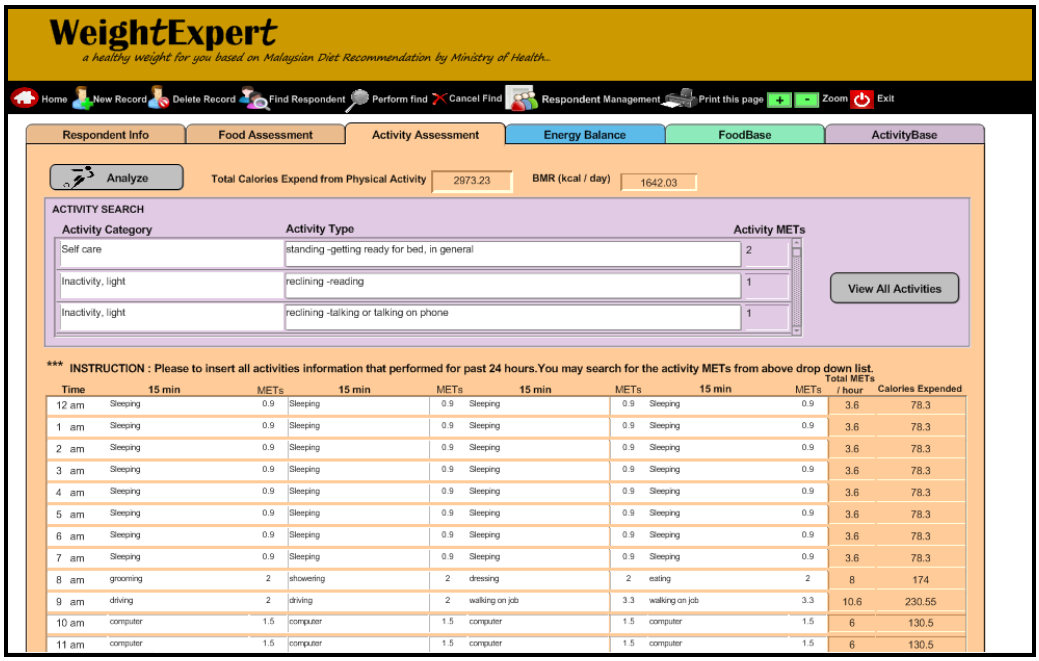
(v) Weight Management Screen: Food Assessment Tab



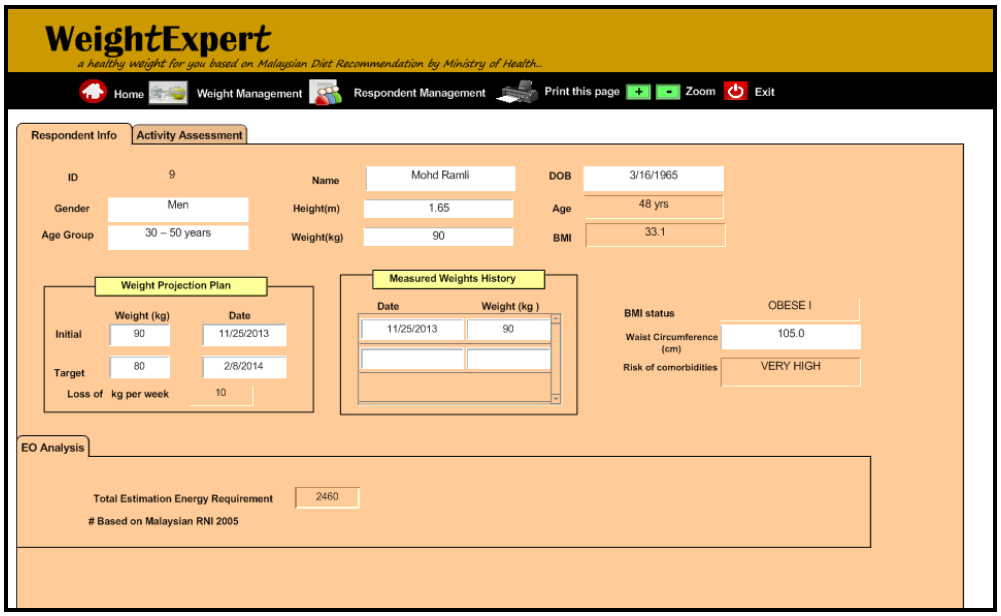
(vi)EI analysis screen



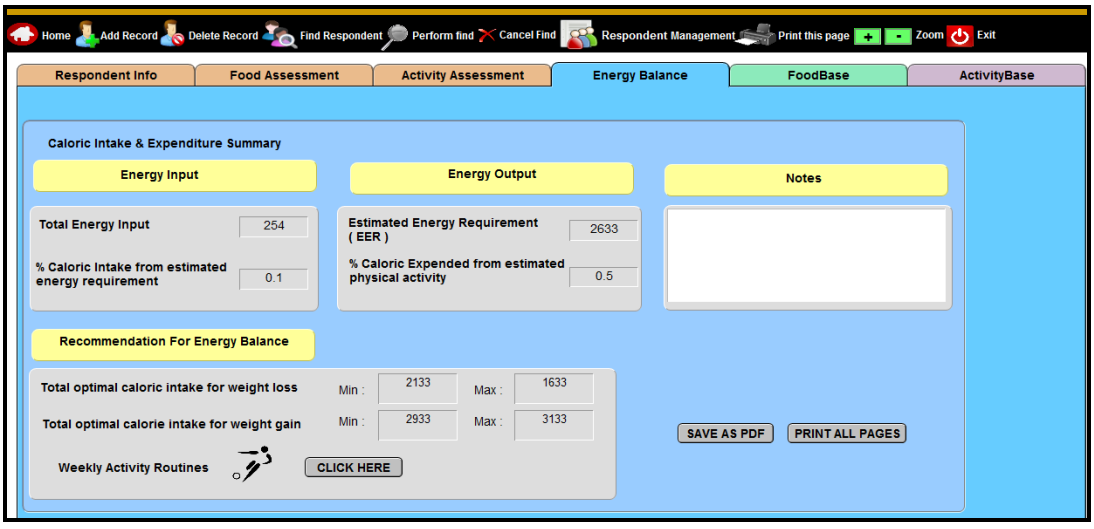
(vii) Weight Management Screen: Activity Assessment Tab



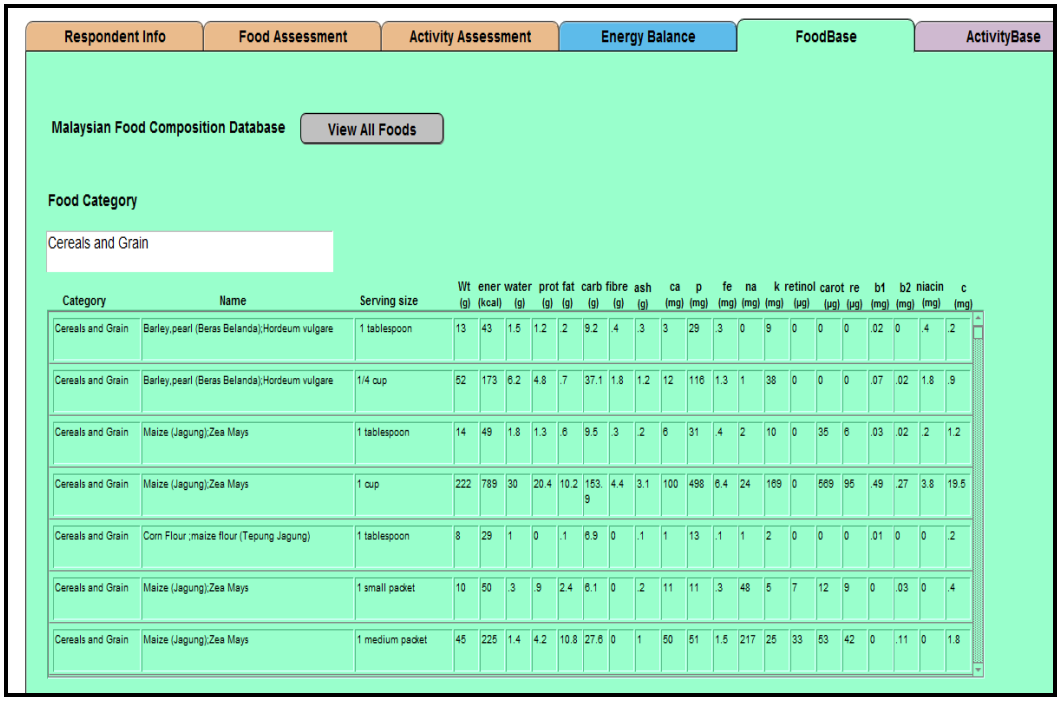
(viii) Energy output (EO) analysis screen



(ix)Weight Management Screen: Energy Balance Assessment Tab

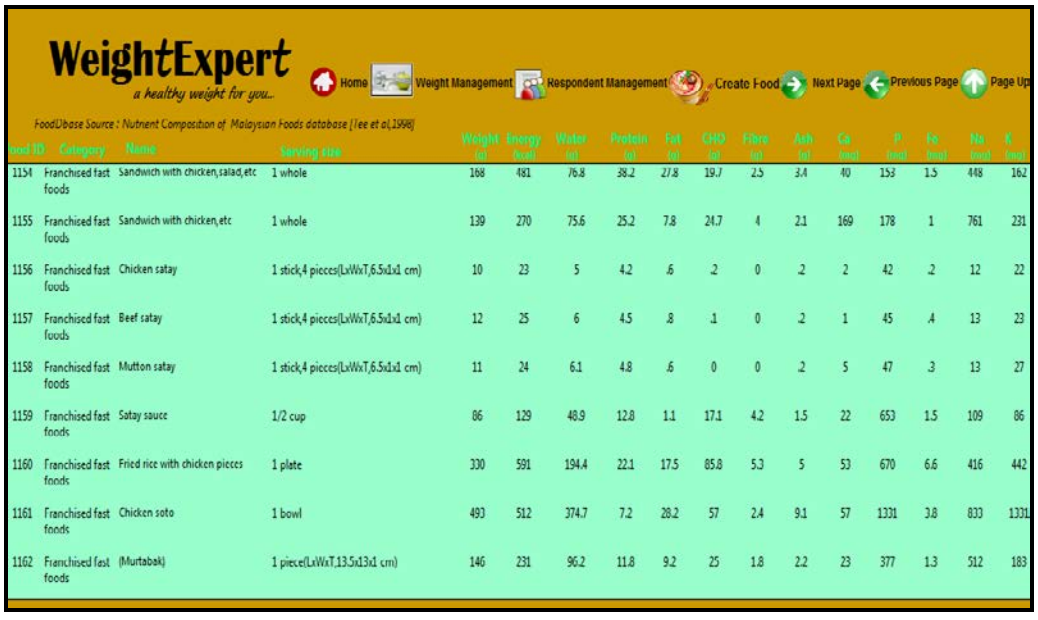


(x) Weight Management Screen: FoodBase Tab



Category	Name	Serving size	Wt (g)	ener (kcal)	water (g)	prot (g)	fat (g)	carb (g)	fibre (g)	ash (g)	ca (mg)	p (mg)	fe (mg)	na (mg)	k (mg)	retinol (µg)	carot (µg)	re (µg)	b1 (mg)	b2 (mg)	niacin (mg)	c (mg)
Cereals and Grain	Barley,pearl (Beras Belanda);Hordeum vulgare	1 tablespoon	13	43	1.5	1.2	.2	9.2	.4	.3	3	29	.3	0	9	0	0	0	.02	0	.4	.2
Cereals and Grain	Barley,pearl (Beras Belanda);Hordeum vulgare	1/4 cup	52	173	6.2	4.8	.7	37.1	1.8	1.2	12	116	1.3	1	38	0	0	0	.07	.02	1.8	.9
Cereals and Grain	Maize (Jagung);Zea Mays	1 tablespoon	14	49	1.8	1.3	.6	9.5	.3	.2	6	31	.4	2	10	0	35	6	.03	.02	.2	1.2
Cereals and Grain	Maize (Jagung);Zea Mays	1 cup	222	789	30	20.4	10.2	153.9	4.4	3.1	100	498	6.4	24	169	0	569	95	.49	.27	3.8	19.5
Cereals and Grain	Corn Flour ;maize flour (Tepung Jagung)	1 tablespoon	8	29	1	0	.1	6.9	0	.1	1	13	.1	1	2	0	0	0	.01	0	0	.2
Cereals and Grain	Maize (Jagung);Zea Mays	1 small packet	10	50	.3	.9	2.4	6.1	0	.2	11	11	.3	48	5	7	12	9	0	.03	0	.4
Cereals and Grain	Maize (Jagung);Zea Mays	1 medium packet	45	225	1.4	4.2	10.8	27.6	0	1	50	51	1.5	217	25	33	53	42	0	.11	0	1.8

(xi)FoodBase for all foods record

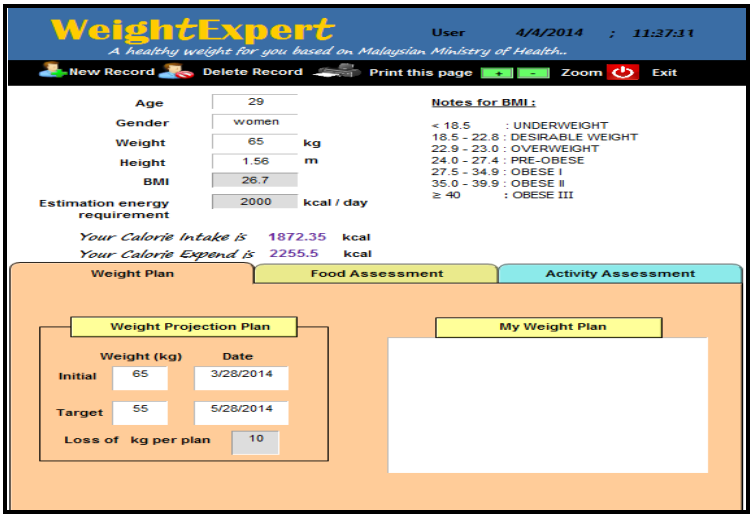


Food ID	Category	Name	Serving size	Weight (g)	Energy (kcal)	Water (g)	Protein (g)	Fat (g)	CHO (g)	Fibre (g)	Ash (g)	Ca (mg)	P (mg)	Fe (mg)	Na (mg)	K (mg)
1154	Franchised fast foods	Sandwich with chicken,salad,etc	1 whole	168	481	76.8	38.2	27.8	19.7	2.5	3.4	40	153	1.5	448	162
1155	Franchised fast foods	Sandwich with chicken,etc	1 whole	139	270	75.6	25.2	7.8	24.7	4	2.1	169	178	1	761	231
1156	Franchised fast foods	Chicken satay	1 stick,4 pieces(LxWxT,6.5x1x1 cm)	10	23	5	4.2	.6	.2	0	.2	2	42	.2	12	22
1157	Franchised fast foods	Beef satay	1 stick,4 pieces(LxWxT,6.5x1x1 cm)	12	25	6	4.5	.8	.1	0	.2	1	45	.4	13	23
1158	Franchised fast foods	Mutton satay	1 stick,4 pieces(LxWxT,6.5x1x1 cm)	11	24	6.1	4.8	.6	0	0	.2	5	47	.3	13	27
1159	Franchised fast foods	Satay sauce	1/2 cup	86	129	48.9	12.8	1.1	17.1	4.2	1.5	22	653	1.5	109	86
1160	Franchised fast foods	Fried rice with chicken pieces	1 plate	330	591	194.4	22.1	17.5	85.8	5.3	5	53	670	6.6	416	442
1161	Franchised fast foods	Chicken soto	1 bowl	493	512	374.7	7.2	28.2	57	2.4	9.1	57	1331	3.8	833	1331
1162	Franchised fast foods	(Murtabak)	1 piece(LxWxT,13.5x13x1 cm)	146	231	96.2	11.8	9.2	25	1.8	2.2	23	377	1.3	512	183

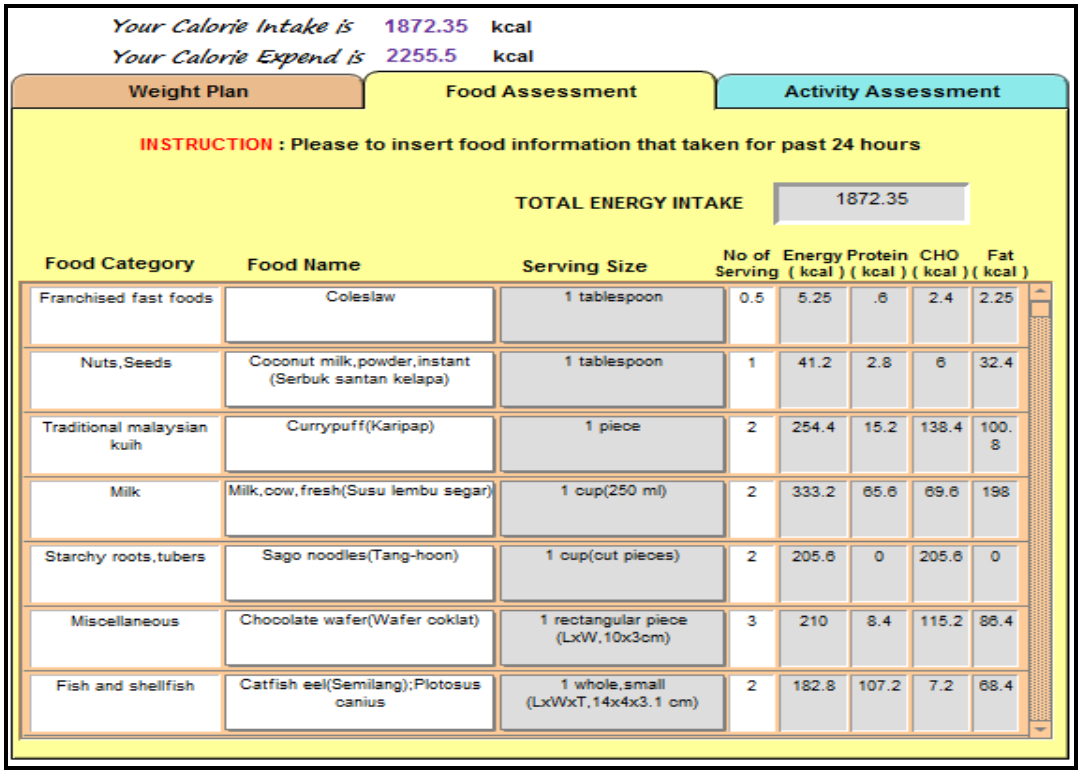
(xii) Weight Management Screen: ActivityBase Tab

(xiii) ActivityBase for all activities record

(xiv) *WeightExpert* DSS screen for public user



(xv) Food Assessment screen for public user



Your Calorie Intake is 1872.35 kcal
Your Calorie Expend is 2255.5 kcal

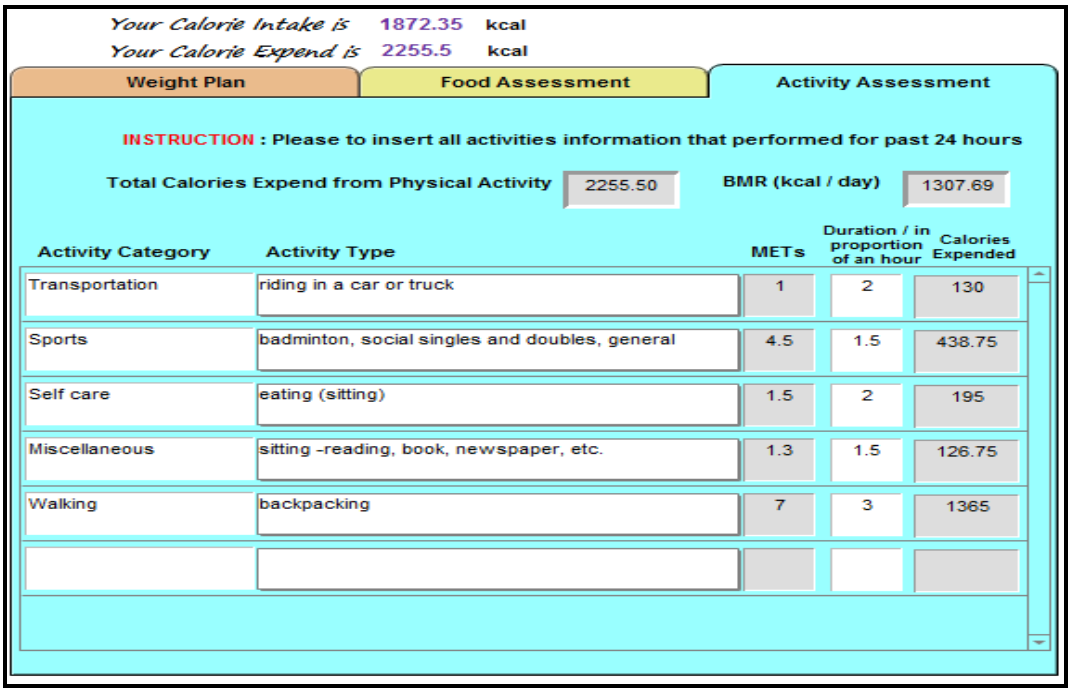
Weight Plan | Food Assessment | Activity Assessment

INSTRUCTION : Please to insert food information that taken for past 24 hours

TOTAL ENERGY INTAKE 1872.35

Food Category	Food Name	Serving Size	No of Serving	Energy (kcal)	Protein (kcal)	CHO (kcal)	Fat (kcal)
Franchised fast foods	Coleslaw	1 tablespoon	0.5	5.25	.6	2.4	2.25
Nuts,Seeds	Coconut milk,powder,instant (Serbuk santan kelapa)	1 tablespoon	1	41.2	2.8	6	32.4
Traditional malaysian kuih	Currypuff(Karipap)	1 piece	2	254.4	15.2	138.4	100.8
Milk	Milk,cow,fresh(Susu lembu segar)	1 cup(250 ml)	2	333.2	65.6	69.6	198
Starchy roots,tubers	Sago noodles(Tang-hoon)	1 cup(cut pieces)	2	205.6	0	205.6	0
Miscellaneous	Chocolate wafer(Wafer coklat)	1 rectangular piece (LxW,10x3cm)	3	210	8.4	115.2	86.4
Fish and shellfish	Catfish eel(Semilang);Plotosus canius	1 whole,small (LxWxT,14x4x3.1 cm)	2	182.8	107.2	7.2	68.4

(xvi) Activity Assessment screen for public user



Your Calorie Intake is 1872.35 kcal
Your Calorie Expend is 2255.5 kcal

Weight Plan | Food Assessment | Activity Assessment

INSTRUCTION : Please to insert all activities information that performed for past 24 hours

Total Calories Expend from Physical Activity 2255.50 BMR (kcal / day) 1307.69

Activity Category	Activity Type	METs	Duration / in proportion of an hour	Calories Expended
Transportation	riding in a car or truck	1	2	130
Sports	badminton, social singles and doubles, general	4.5	1.5	438.75
Self care	eating (sitting)	1.5	2	195
Miscellaneous	sitting -reading, book, newspaper, etc.	1.3	1.5	126.75
Walking	backpacking	7	3	1365

Appendix B: Introduction of Questionnaire

WeightExpert Usability Study

Introduction to the Study

This experiment is part of a research study evaluating the usability of the WeightExpert application for Malaysian Adult Weight Management . Aadilah Baharuddin, a master's degree student from University of Malaya, Kuala Lumpur, is conducting this study. Data gathered from the study will assist the researcher in making appropriate enhancements and alterations to the WeightExpert application for future users.

What is WeightExpert application ?

A tool for monitoring individual body weight by keeping track on their food consumption and physical activity .User also enable to compare total calorie intake with total estimation energy requirement per day based on Recommended Nutrient Intakes (RNI) for Malaysia (MOH,2005) and follows by balance it with calorie expenditure through physical activity.

Energy balance is achieved when calorie intake from food intake is balanced with calorie expenditure.Individuals gain weight whenever their calorie or energy intake exceeds their energy expenditure. Individual loses weight when their energy expenditure exceeds energy intake.

An important part of maintaining energy balance is the amount of energy out (through physical activity) that individual do. Adult who is more physically active will burn more calories than those who are not as physically active. For example an adult can burn calories by walking to the bus stop, going shopping, jogging and etc.

Data sources used:

1) Nutrient Composition of Malaysian Foods 4th edition by Tee E Siong, Mohd. Ismail Noor, Mohd Nasir Azudin, Khatijah Idris,c/o Institute for Medical Research, Kuala Lumpur,1997
2) Compendium of physical activities: an update of activity codes and MET intensities by Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR Jr, Schmitz KH, Emplaincourt PO, Jacobs DR Jr, Leon AS. Med Sci Sports Exerc. 2000 Sep;32(9 Suppl):S498-504.
3) Recommended Nutrient Intake (RNI) for use in Malaysia (MOH,2005)

What Will Happens During the Study.

To participate in the experiment, you will:
1. Test the application
2. Complete a questionnaire on two aspects, which are Profile and User Interface and Satisfaction while Health Professionals are required to complete also on Perceived Usefulness

Your Privacy is Important

- We will make every effort to protect your privacy
- All identifying data on the questionnaires will be kept strictly confidential
- We will not use your name in any of the information we get from this study or in any of the research reports
- When the study is finished, all identifying information will be destroyed.

If you have questions or concerns about participating in this study, please contact :aadilah2013@gmail.com

Appendix C: User Profile Questionnaire

WeightExpert Usability Study

Evaluating the Usability of the WeightExpert

Thank you for participating in this study.

INSTRUCTIONS
1. This questionnaire is divided into 3 sections.
Section A: Profile
Section B :Perceived Usefulness (Only for Health Professionals)
Section C: User Interface and Satisfaction
2. Please respond to all the items.
3. For items that are not applicable, use: N/A

Section A :Profile

Name / Email

Department / Clinic

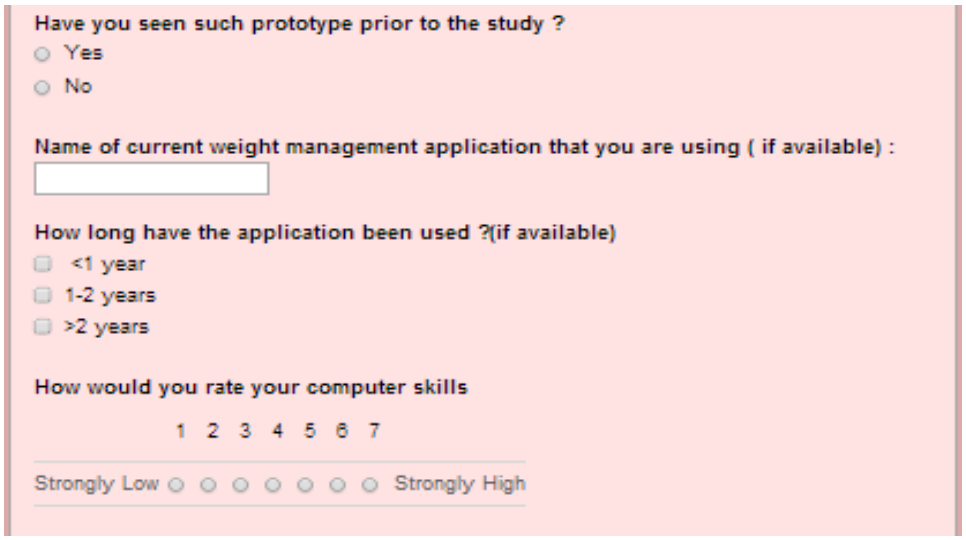
Position
- ☐ Health Professionals (Dietitian,Nutritionist etc)
- ☐ Public User
- ☐ Other:

Age
- ☐ 18-29
- ☐ 30-59

Gender
- ☐ Female
- ☐ Male

Please indicate the highest level of education completed
- ☐ High School or equivalent
- ☐ Vocational/Technical School
- ☐ College
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Professional Degree
- ☐ Other:

Appendix C: User Profile Questionnaire (continued)



Have you seen such prototype prior to the study ?

- Yes
- No

Name of current weight management application that you are using (if available) :

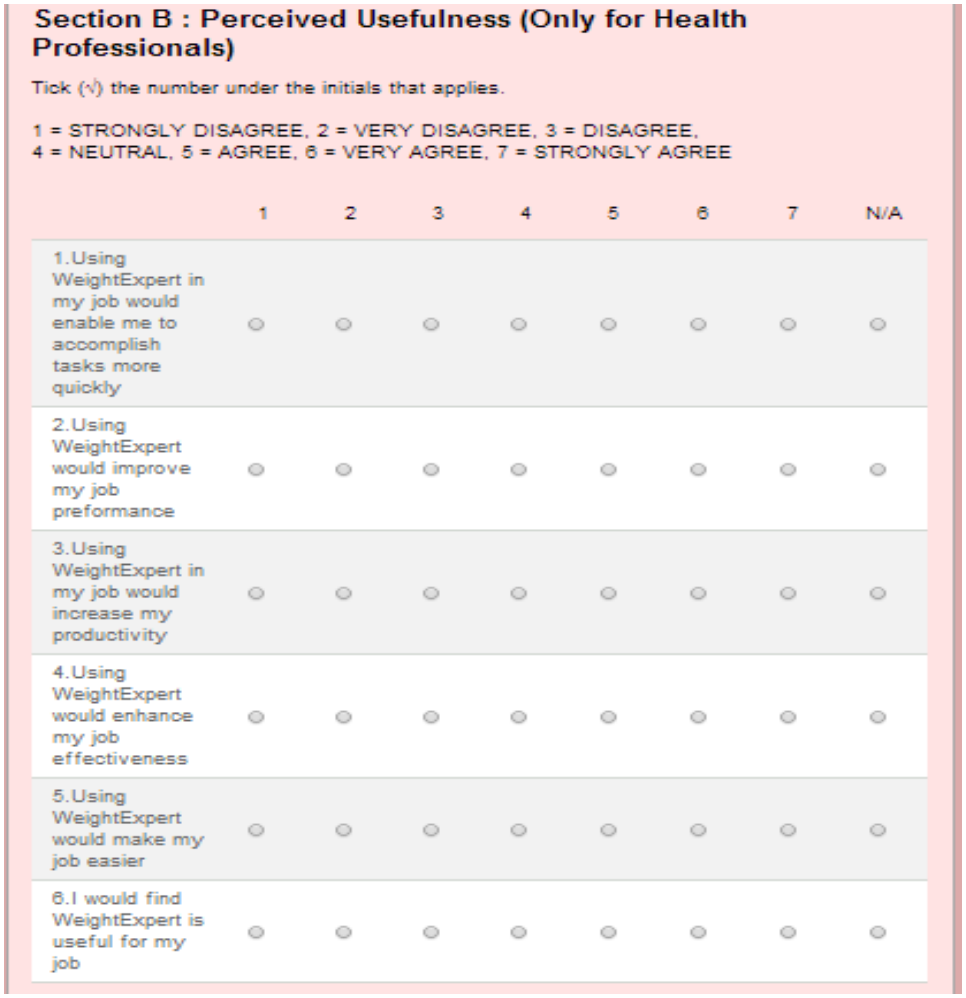
How long have the application been used ?(if available)

- <1 year
- 1-2 years
- >2 years

How would you rate your computer skills

	1	2	3	4	5	6	7	
Strongly Low	○	○	○	○	○	○	○	Strongly High

Appendix D: Perceived Usefulness Questionnaire



Section B : Perceived Usefulness (Only for Health Professionals)

Tick (√) the number under the initials that applies.

1 = STRONGLY DISAGREE, 2 = VERY DISAGREE, 3 = DISAGREE,
4 = NEUTRAL, 5 = AGREE, 6 = VERY AGREE, 7 = STRONGLY AGREE

	1	2	3	4	5	6	7	N/A
1.Using WeightExpert in my job would enable me to accomplish tasks more quickly	○	○	○	○	○	○	○	○
2.Using WeightExpert would improve my job preformance	○	○	○	○	○	○	○	○
3.Using WeightExpert in my job would increase my productivity	○	○	○	○	○	○	○	○
4.Using WeightExpert would enhance my job effectiveness	○	○	○	○	○	○	○	○
5.Using WeightExpert would make my job easier	○	○	○	○	○	○	○	○
6.I would find WeightExpert is useful for my job	○	○	○	○	○	○	○	○

Appendix E: User Interface and Satisfaction Questionnaire

Section C : User Interface and Satisfaction

Tick (√) the number under the initials that applies.

1 = STRONGLY DISAGREE, 2 = VERY DISAGREE, 3 = DISAGREE,
4 = NEUTRAL, 5 = AGREE, 6 = VERY AGREE, 7 = STRONGLY AGREE

Overall reactions to the WeightExpert

	1	2	3	4	5	6	7	N/A
1.The WeightExpert is wonderful	○	○	○	○	○	○	○	○
2.The WeightExpert is easy to use	○	○	○	○	○	○	○	○
3.I am satisfying with the WeightExpert	○	○	○	○	○	○	○	○
4.The WeightExpert is adequate power	○	○	○	○	○	○	○	○
5.The WeightExpert is flexible	○	○	○	○	○	○	○	○

Screen

	1	2	3	4	5	6	7	N/A
6.The menu items are well organized and functions are easy to find.	○	○	○	○	○	○	○	○
7.I immediately understood the function of each menu item.	○	○	○	○	○	○	○	○
8.All of the functions I expected to find in the menus are present.	○	○	○	○	○	○	○	○
9.The buttons are well organized and easy to find.	○	○	○	○	○	○	○	○
10.I immediately understood the function of each button.	○	○	○	○	○	○	○	○
11.All of the functions I expected to find on the button bar are present	○	○	○	○	○	○	○	○

Appendix E: User Interface and Satisfaction Questionnaire (Continued)

Terminology

	1	2	3	4	5	6	7	N/A
12.The used of terminologies throughout the WeightExpert are consistence.	○	○	○	○	○	○	○	○
13.Terminology always relates well to the work you are doing	○	○	○	○	○	○	○	○
14.Instruction for commands or functions is clear.	○	○	○	○	○	○	○	○
15.Error messages prompt out on the screen is helpful.	○	○	○	○	○	○	○	○
16.Performing an operation always leads to a predictable result.	○	○	○	○	○	○	○	○

Learning

	1	2	3	4	5	6	7	N/A
17.Learning to use the WeightExpert is easy.	○	○	○	○	○	○	○	○
18.Time to learn to use the WeightExpert is fast.	○	○	○	○	○	○	○	○
19.Tasks can always be performed in a straightforward manner.	○	○	○	○	○	○	○	○
20.Number of steps per task is just right.	○	○	○	○	○	○	○	○
21.Steps to complete a task always follow a logical sequence	○	○	○	○	○	○	○	○

WeightExpert Capabilities

	1	2	3	4	5	6	7	N/A
22.WeightExpert speed (to open or launch program) is fast enough.	○	○	○	○	○	○	○	○
23.WeightExpert speed (to navigate within the system) is fast enough.	○	○	○	○	○	○	○	○
24.The WeightExpert is always reliable.	○	○	○	○	○	○	○	○
25.The WeightExpert failure seldom occurred.	○	○	○	○	○	○	○	○

Appendix E: User Interface and Satisfaction Questionnaire (Continued)